A Fisheries Management Plan for Louisiana's Penaeid Shrimp Fishery

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Office of Fisheries

December 31, 1992

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Executive Summary

The shrimp fishery is Louisiana's largest commercial fishery, accounting for over 85% of the value of the state's edible fisheries production.

The fishery is based on two species, white shrimp, (Penaeus setiferus Linnaeus) and brown shrimp, (P. aztecus Ives). Three other species are also harvested to a much lesser degree: sea bobs (Xiphopenaeus kroyeri Heller), pink shrimp (P. duorarum) and royal red shrimp (Hymenopenaeus robustus). Though Louisiana is the center of abundance of white and sea bob shrimp, and with Texas is the center of abundance of brown shrimp, none of these five species are restricted to Louisiana's waters. Therefore, maximum sustainable yields are not computed for this plan, since such consideration is a regional feature of these species.

The life cycles of white, brown, and pink shrimp are comparatively similar. They mature during their first year of life and spawn in the open waters of the Gulf of Mexico. Fertilized eggs hatch into planktonic larvae which enter the state's estuaries by mechanisms which are just beginning to be understood. Within the estuary the tiny larvae, which are 7-15 millimeters (mm) in total length (TL) become bottom feeders, seeking the food rich resources of the shallow bays and flooded marshes. Growth and survival within the estuary is highly dependent upon the prevailing temperature and salinity regimes, which dictate to a very large degree the potential seasonal harvest. Under optimum conditions juveniles exhibit rapid growth, in excess of 1 mm/day, and move to the state's open bays at a size of 70 to 100 mm TL. These open bays serve as a "staging area" where the shrimp continue to grow until they either reach the size which triggers their emigration to the open Gulf or until adverse estuarine conditions stimulate an early emigration at a smaller size. These three species of shrimp are harvested from the state's estuarine and territorial seas, as well as similar waters of adjacent states and the adjoining federal waters of the Gulf.

Comparatively little is known about sea bob and royal red shrimp. Sea bobs spend their entire life in the Gulf of Mexico and are usually harvested in association with white shrimp. Royal red shrimp are found in depths of 300 to 400 fathoms.

There are typically two inshore shrimp seasons during the year: a spring season, lasting from mid-May to the beginning of July for the harvest of brown shrimp and a fall season, from mid-August to mid-December, to harvest white

shrimp. Special seasons are occasionally opened in the inshore waters to harvest untypical concentrations of marketable shrimp.

The offshore state waters (from the coastline to 3 miles offshore) have been historically open to shrimp harvest the entire year; recently this area has been occasionally closed for varying periods in January-April.

White and brown shrimp account for 93-96% of Louisiana's shrimp landings by poundage. The remaining landings are comprised of sea bobs, pink shrimp, and rock shrimp.

From 1976-1990 40% of reported Louisiana landings were taken in inshore state waters, 43% were taken in the state's offshore waters and 17% were taken in the Federal waters off of Louisiana's coast.

About seven million pounds of shrimp are reportedly caught annually in inshore state waters and landed in other states. In the federal waters off of Louisiana, one-third to one-half of the catch is landed in other states.

From 1970-1990 just over 40% of the Gulf of Mexico landings were landed in Louisiana. Both absolute landings and share of Gulf landings have increased during that period. Some scientists have hypothesized that this increase is caused by an increase in shrimp habitat resulting from deterioration of the wetlands along coastal Louisiana. If this is the case, Louisiana catch may begin to decline within the next 15-20 years.

The landings of large shrimp (greater than 30 count headless) have decreased since 1970 both in absolute terms and as a proportion of total landings; in 1990 they were less than 12% of total landings. The proportion of medium size shrimp (31-67 count headless) has remained stable at 27-29% of the total. The proportion of small shrimp (greater than 67 count headless) has increased in the past 20 years and has averaged near 60% since the mid 1980's. Louisiana accounts for about 70% of the Gulf production of small shrimp. The reduction in average size of shrimp landings seems to be the result of harvesting smaller white shrimp; the relative size distribution of brown shrimp landings has been relatively stable since 1970. More than 80% of small brown shrimp are landed in May and June; 95% are landed from May-July. Over the years the proportion of small brown shrimp landed in May has increased, probably the result of increasing effort at the opening the spring inshore season. 85-90% of medium brown shrimp are landed from June-August. The landings of large brown shrimp peak in August.

In the late 1970's the peak landings of small white shrimp occurred in November; in the 1980's the peak landings of small white shrimp occurred in October, perhaps as the result of increased shrimping effort in the earlier months. The same situation occurred for medium white shrimp. In the 1970's peak production of this size occurred in September/November. In the

1980's peak production occurred in August.

Much of the increase in dockside shrimp price and related value in recent years has been the result of inflation. The deflated dockside price of shrimp landed in Louisiana peaked in the late 1970's and has since fallen steadily. This decrease is the result of increasing shrimp imports and of the increase in proportion of small shrimp landed; the impact of imports is thought to have been much greater than the impact of a smaller size of shrimp. However, because of the smaller size of shrimp landed, Louisiana's dockside per-pound shrimp price is the lowest among the Gulf states. The price of shrimp landed by butterfly nets is significantly lower than that of trawls, largely because smaller size shrimp are harvested with that gear.

About 16 thousand persons participated in the commercial harvest of shrimp in 1991. The number of commercial harvesters has declined in recent years. A large proportion (> 75%) of the commercial harvesters are part-time. A substantial number of state license holders purchase commercial licenses but do not sell their catch; they wish to catch more than the recreational daily limit of shrimp. Both the number of harvesters and the amount of fishing effort peaked in the late 1980's and have declined in the early 1990's.

A large proportion of Louisiana's shrimp fleet is comprised of boats thirty feet or less in size, however there is a trend towards larger vessels. In 1991 almost 80% of the vessels were thirty feet or less in length; only 6% were greater than fifty feet in length. The average age of boats greater than fifty feet is 18 years; the average age of boats 20-30 feet in length is 9 years. In the late 1970's vessels appreciated in value; in the late 1980's boats were depreciating in value.

There is relatively little movement of harvesters between shrimp zones; 90% of full-time shrimpers fish exclusively in one inshore zone. Among part-time shrimpers almost all shrimping occurred exclusively in one zone. Mobility increases with vessel size; 25-30% of the largest vessels shrimp in more than one zone.

Trawls and butterfly nets are the primary gears used in harvesting Louisiana's shrimp, although skimmers are reportedly becoming more common. Trawls account for over 90% of Louisiana's reported shrimp landings.

Many of the smaller boats in the shrimp fleet sell their catch directly to the consumer; one-half of commercial licensed shrimpers with boats less than 20 feet in length bypass shrimp dealers and about 20% of the part-time commercial licensed shrimpers with boats 20-30 feet in length bypass dealers. As a result, the state's reported shrimp landings may underestimate actual landings by a significant amount, perhaps as much as 20%. Much of this unreported catch is in the smaller size categories.

Dealers are generally the first middlemen to take possession of shrimp once the

catch reaches the dock. Dealers typically provide docking and other services to the harvester, including credit, free docking and bonuses. Three quarters of these handlers are vertically or horizontally integrated with other segments of the shrimp fishery.

Louisiana's shrimp processors are not very diverse; most deal only in shrimp and use the local supply. Imports consist of a very small percentage the total poundage utilized, but useage of imports is increasing. Employment in this industry is seasonal; about one thousand workers were employed annually in the late 1980's.

Processing activities are an important function in that they add value to harvested shrimp, provide the product in a form desired by the consumer, and are a source of additional employment for the state's work force. In-state processing activities have not kept pace with expanded shrimp landings. On a deflated basis (1990 CPI), the value of Louisiana's shrimp processing activities peaked during 1976-1978 at $250 million; since then this value has fallen more than 45% to $133 million in 1988-1990. This decline is the result of a moderate reduction in the amount of pounds processed and a larger reduction in the price of the shrimp processed. While Louisiana's processing activities were declining, the pounds of shrimp processed Gulfwide increased during 1973-1990, largely the result of increased usage of imported shrimp. Louisiana's share of Gulfwide processing activities declined in terms of value from 24% in 1973-1975 to 14% in 1988-1990. The only processing component that has grown since 1970 is peeling.

The Louisiana Legislature has placed the shrimp industry under the supervision and control of the Louisiana Wildlife and Fisheries Commission (commission). The commission has the authority to set seasons based on technical and biological data which indicate that marketable shrimp, in sufficient quantities, are available for harvest. The Legislature has reserved to itself the right to determine legal gear, licenses and fees, legal sizes, and other aspects of the fishery.

Recommended enhancements to the fishery which have been implemented since 1970 include the flexible opening of the inshore brown and white shrimp seasons and the division of the coastal estuaries into three management zones. These measures have allowed the Department and Commission to increase the yield of shrimp by adjusting the seasonal openings to accommodate the environmentally controlled growth and recruitment patterns of the juvenile brown and white shrimp.

Other potential enhancements, which have long been recommended by the Department and Commission remain as major potential benefits to the fishery. These are: 1) creation of sanctuaries to protect shrimp which are too small to be marketed , 2) limitation on and reduction of effective fishing

effort, and 3) habitat stabilization, protection, and enhancement. In addition, there is the potential to increase the poundage and value of shrimp landed through seasonal delays in the harvest of white and brown shrimp.

Sanctuaries would prevent waste and increase yield and exvessel value in the fishery. Shrimping effort would be redirected to the major estuarine bays and open waters of the Gulf, reducing growth-overfishing on both white and brown shrimp and allowing for a longer open inshore season.

A limit and reduction in effective fishing effort, if properly instituted, would increase yield, exvessel value, and profit. Because Louisiana's shrimp fishery is multijurisdictional, effort limitations would have little long term benefit without support from the other state and federal management organizations.

Protection of the present prime habitat and restoration of degraded habitats is needed for continued viability of the resource and fishery.

Major threats to the viability of the present fishery are: 1) habitat loss and pollution, 2) importation of shrimp, especially maricultured shrimp, 4) unlimited effort, and 5) expansion of the harvest into shrimp smaller than the current minimum sizes.

The proposed shrimp management option which is most complex from a legal viewpoint is a limited/reduced effort program. There are several constitutional issues that must be considered: substantive due process; unconstitutional "taking" of private property; regulation on interstate commerce; equal protection; and privileges and immunities protections for citizens. Each of these issues is discussed herein.

The Chronological History of Shrimp Legislation in Louisiana shows that the three most common legislative topics were delineation of the inside-outside shrimp line, the dates for seasons, and the regulation or prohibition of certain types of gear. A review of the Chronological History indicates that some of the topics regulated by statutes would be more appropriately regulated by Commission regulations, subject to legislative oversight of such regulations.

Chapter 1 - Introduction

Estimated at dockside, shrimp consistently ranks as Louisiana's largest commercial fishery by value. With exceptions, the fishery contributes 55%-65% of the state's total saltwater fish and shellfish harvest and in excess of 85% of the value of the state's edible production.

The value of Louisiana's seafood landings in 1990, excluding aquaculture production, equalled $279 million at dockside. The value of the state's shrimp landings for the same year equalled $153 million, or 55% of the total. This value exceeded that of the state's menhaden fishery ($41.7 million) by a factor of more than three, the value of the state's oyster industry ($29.9 million) by a factor of five, and the state's blue crab fishery ($14.2 million) by a factor exceeding ten.

This management plan addresses the problems and potentials of Louisiana's penaeid shrimp fishery. The plan was developed by a project jointly funded by the U.S. Department of Commerce (DOC), Louisiana State University (LSU), and the Louisiana Department of Wildlife and Fisheries (LDWF). The DOC provided funding through a NOAA-NMFS MARFIN Project. LSU experts including a biologist, an economist, and an attorney provided the scientific information necessary to evaluate the management options suggested by the Department of Wildlife and Fisheries. The early development of the plan was guided by the goal of "maximizing the economic benefits of the fishery to Louisiana and the region". Subsequent review of the draft plan by the Louisiana Wildlife and Fisheries Commission's Shrimp Management Committee (committee) resulted in refining the set of feasible management actions and a elaboration of the management goals. After review by the committee, public comment was solicited. The final product of this process is a set of proposed actions to be addressed by the Louisiana Wildlife and Fisheries Commission and the Louisiana Legislature in the future management of the fishery.

Chapter 2 - Description of the Fishery

A large number of groups depend on Louisiana's shrimp resources for all or part of their livelihood. Most recognized among these groups is the commercial shrimper (i.e. harvester). After bringing in his catch, the commercial harvester will either sell it to a dealer or processor, or market it directly to the consumer. Dealers and processors take the shrimp as landed, provide a variety of marketing services to it and resell the product to brokers, wholesalers, retailers, restaurants, etc. These marketing services add additional value to the product and provide additional employment opportunities.

Commercial Harvesters

Number of Commercial Harvesters

The state of Louisiana currently issues commercial shrimp gear licenses to about 15 thousand of its residents. These individuals and their crews earn the majority of their income, or supplement their annual income, through shrimping activities. Several thousand non-resident commercial shrimpers also shrimp in Louisiana waters each year.

Two methods can be used to ascertain participation in Louisiana's commercial shrimp harvesting sector. The first utilizes commercial shrimp licenses issued by the Louisiana Department of Wildlife and Fisheries (LDWF). The second utilizes information gathered by the National Marine Fisheries Service (NMFS). Neither of these data sets is completely satisfactory for measuring commercial participation in Louisiana's shrimp harvesting sector.

For several reasons, licenses issued by LDWF may partially distort accurate measurement in Louisiana's shrimp harvesting sector. First, residents and/or nonresidents may purchase a

commercial shrimp gear license but not use it for commercial purposes. Keithly and Mounce (1990), in a 1987 study of Louisiana's inshore shrimp fishery, found that a significant number of licensed shrimpers did not sell their catch. A second reason why licenses issued by LDWF partially distort accurate measurement of participation is that license sales do not account for crews on shrimp boats. A final reason why shrimp license sales do not accurately reflect participation is that unless the shrimp is landed in Louisiana no license is required if the boat shrimps exclusively in Federal waters.

The National Marine Fisheries Service provides an estimate of the number of vessels (a craft having a capacity of five net tons or more) and boats (a craft having a capacity of less than five net tons), along with the associated number of fishermen, shrimping in Louisiana's state waters and Federal waters. The number of shrimp vessels is based on the NMFS Vessel Operating Units file which is a Coast Guard based file supplemented with NMFS data. The number of boats has traditionally been estimated from dealer interviews. More recently, however, estimates of boats are determined at least partially on LDWF license sales (Mr. Lee Usie, NMFS,pers. comm.). One potential problem of NMFS estimates is that no accounting is made for shrimpers who bypass traditional marketing channels when selling their catch. Keithly and Mounce (1990), Roberts and Sass (1980), and Nance et. al (1991), have reported significant direct sales of shrimp by smaller boats.

With these caveats stated, resident and nonresident commercial fishing licenses issued by LDWF for the 1977-91 period are provided in Table I. NMFS estimates of vessels and boats, and related number of fishermen, are presented in Table II.

The number of resident commercial shrimping licenses issued by LDWF equalled more than twenty-thousand in 1987 compared to less than fifteen thousand in 1991, a decline of more than 25% in only five years. The number of nonresident commercial shrimping licenses also declined, though the decline began several years earlier. In 1991, 12,452 residents were issued one or more trawl licenses, 4,282 residents were issued one or more butterfly licenses, and 2,136 residents were issued both gear licenses. Overall, the numbers indicate that participation in Louisiana's shrimp harvesting sector in 1991, excluding crew, equalled 16,074, comprised of 14,598 residents and 1,476 nonresidents. Licenses issued by parish for 1990 and 1991 (Table III), suggest that almost one-half of the total licenses were issued to residents of Jefferson, Terrebonne, and Lafourche Parishes ; adding Plaquemines, St. Bernard, and St. Mary Parishes accounts for two-thirds of total license sales.

The National Marine Fisheries Service estimates of participation at the harvesting

level, which include crew and all activity in Federal waters, indicated 17,651 shrimp fishermen in 1989, fishing from 4,073 vessels and 4,940 boats. This number, which includes crew members, is less than the 18,966 resident and nonresident commercial shrimp licenses issued by LDWF in 1989, highlighting some of the discrepancies between the two data sources. According to NMFS estimates, the number of vessels fishing in state and federal waters off Louisiana more than doubled between 1977 and 1989, from 1,663 to 4,073. This number includes vessels from other Gulf states that may have made as few as one trip in Louisiana in 1989. The number of fishermen per vessel increased marginally, from an average of 2.36 to 2.65.

According to NMFS estimates, the number of boats operating in Louisiana's shrimp fishery increased from 3,844 in 1977 to 6,013 in 1987 and then declined to 4,940 in 1989. Regular and casual shrimp fishermen per boat equalled 1.32 in 1977 compared to 1.39 in 1989.

Full-time Versus Part-Time Participation

In a broad sense, participants in Louisiana's commercial shrimp harvesting sector can be partitioned into two categories: full-time and part-time shrimpers. The distinction between these categories, however, is open to interpretation. This is because shrimping activities, such as number of trips or days fished, follow a continuum with no distinct point of demarkation .

In a 1978 survey of Louisiana's shrimp fleet, Sass and Roberts (1979) distinguished between full-and-part time boat shrimp captains, i.e. captains of non documented vessels, according to non-fishing activities. If the boat captain had outside employment, was retired, or was a student, he was considered part-time. Based on this criteria, the authors estimated that almost 90% of Louisiana's shrimp boat fleet was part-time in nature. All vessel captains were considered full-time shrimpers.

Keithly and Mounce (1990) conducted a survey of the 1987 commercial shrimp fleet. Their study was limited to the coastal parishes and those parishes surrounding Lake Ponchartrain; which accounted for about 85% of all commercial shrimp license sales in that year. In their survey, Keithly and Mounce asked the shrimpers whether they considered themselves to be full-time shrimpers when inshore waters were open. This method of distinguishing between full-and-part time shrimpers was more liberal than that used by Sass and Roberts and resulted in more liberal results.

Overall, 40% of the surveyed participants (who sold their catch) considered themselves full-time shrimpers when inshore waters were open. Among shrimpers of boats less than 20 feet in length, only about 4% considered themselves full-time. Among shrimpers with boats 20-30 feet in length, about 45% of the

respondents considered themselves full-time shrimpers when inshore waters were open. Almost 95% of shrimpers with boats greater than 30 feet in length considered themselves full-time shrimpers. Less than four percent of the full-time shrimpers held other jobs during the inshore seasons, according to the results presented by Keithly and Mounce.

In a geographically limited study of Calcasieu Lake's inshore shrimp fishery, Nance et. al. (1991) reported that 54% of the Calcasieu Lake shrimpers stated that they were fully dependent on shrimping activities for monetary support. The proportion increased with boat size.

A few comments are warranted regarding the timing and interpretation of these studies. First, the study by Sass and Roberts was conducted almost 10 years previous to the studies of Keithly and Mounce, and Nance et .al. Unemployment in the coastal parishes at the time of the Sass and Roberts survey was relatively low, less than five percent. In 1987, when Keithly and Mounce, and Nance et. al. conducted their surveys, unemployment in coastal parishes was greater than ten percent and approached 20% in some parishes. Keithly and Mounce reported that increased shrimping activities were the result of limited job opportunities elsewhere in the economy. As noted by the authors, many of the shrimpers who considered themselves full-time at the time of the study had previous shrimping experience as part-time shrimpers; they increased their shrimping activities only after the decline in the coastal economy. The estimates provided by Keithly and Mounce related only to shrimpers in the coastal communities and around Lake Ponchartrain. Undoubtedly, most of the shrimpers residing in parishes not surveyed (about 15% of the total) would consider themselves part-time in nature. The authors therefore concluded that the "true" percentage of full-time shrimpers was probably closer to 25% and that the percentage of full-time shrimpers is related to the economic situation.

Experience

Based on their 1978 survey of Louisiana shrimp vessels, Sass and Roberts reported that captains of vessels less than 66 feet in length averaged 17 years of shrimping experience, captains of vessels $\geq$66 feet in length averaged 19 years of shrimping experience, and boat captains averaged 11 years of shrimp experience.

Based on the 1987 survey of Louisiana's inshore shrimpers, Keithly and Mounce reported that full-time shrimpers of boats 20-30 feet in length averaged 12 years of shrimping experience, full-time shrimpers of boats >30-50 feet in length averaged 13 years as captain, and full-time shrimpers of boats in excess of 50 feet in length averaged 15 years of experience in shrimping. These numbers compare favorably to those reported by Sass and Roberts.

Mobility

Sass and Roberts reported that vessel and boat mobility between the state's three management zones was relatively minor in 1978. Among boat captains residing in the Central and Western Zones, more than 90% of the aggregate inshore shrimping time occurred in the zone of residence. Captains of boats and vessels who resided in the Eastern Zone reported that 63% of their inshore shrimping time occurred in the Eastern Zone.

From their analysis on mobility, Sass and Roberts concluded that mobility is not likely to significantly impact shrimp management. They clarify this, however, by stating "[o]ne caution is that the 10 percent of shrimping occurring outside of a home zone can take place for a short period of time. This mobile effort for a short period immediately following an opening date can result in a different conclusion. It can increase crowding externalities and the stress placed on fuel, ice, and market services (p.6)".

Keithly and Mounce also investigated mobility between zones in Louisiana's inshore shrimp fishery for 1987. They found that about 90% of full-time shrimpers fished exclusively in one inshore zone during the brown shrimp season and 91% during the white shrimp season. Among part-time shrimpers, almost all shrimping time occurred exclusively in one zone.

Keithly and Mounce further indicated that mobility increased with boat size. For example, 95% of full-time shrimpers of boats 20-30 feet in length shrimped exclusively in one zone during the brown shrimp season and the same proportion held in the white shrimp season. Eighty-five percent of full-time shrimpers of boats >30-50 feet in length reported shrimping in only one inshore zone during the brown shrimp season while almost 88% reported shrimping exclusively one zone during the white shrimp season. About 77% of full-time shrimpers of boats in excess of 50 feet shrimped in only one zone during the 1987 brown shrimp season while 83% shrimped in only one zone during the white shrimp season.

The authors further indicate that there was more movement of residents of the Eastern Zone into the Central Zone during the 1987 inshore white shrimp season than the 1987 inshore brown shrimp season. This occurred even though the Eastern Zone was closed 19 days prior to the closing of the Central Zone during the brown shrimp season (all zones opened on the same day). The authors hypothesized that this may reflect the fact that the catch of white shrimp in the Eastern Zone was, reportedly, well below normal in 1987. This suggests that mobility may be related to expected catches in the different zones, especially if catch in a given zone is abnormally low vis-a-vis other zones.

Overall, results provided by Keithly and Mounce confirm those reported by Sass and Roberts; i.e., mobility is relatively minor.

Commercial Vessels

Size Distribution

Estimates of size distribution of boats used by residents for commercial shrimping purposes are presented in Table IV for the 1977-91 period. These numbers are based on LDWF license sales. The distribution four size classes: <20 foot boats, 20-30 foot boats, >30 ft-50 ft boats, and >50 foot boats.

As indicated, a large but declining share of Louisiana's shrimp fleet is comprised of boats thirty feet or less in length. In 1987, for example, 46% of the resident commercial shrimp boats were less than 20 feet in length while 84% were less than 30 feet in length. Only about five percent of the total exceeded 50 feet in length.

By 1991, the proportion of resident commercial shrimp boats ≤20 feet in length had fallen to less than 40% of the total while boats less than 30 feet in length equalled less than 80% of the total. The share represented by boats in excess of 50 feet in length, increased to 6.3%.

From 1988 to 1991 boats less than 20 feet in length decreased 35%, boats from 20-30 feet in length decreased 26%, boats >30-50 feet in length decreased 12%, and boats in excess of 50 feet in length decreased almost 10%. In all but the largest boat class (>50 feet), the number of registered boats in 1991 was less than the number reported in 1981.

Age of Boats

In a 1978 study of Louisiana shrimp vessels, Roberts and Sass (1980) reported that the average age of vessels ≤50 feet, i.e. Coast Guard documented craft, was 15 years. Vessels from 51-65 feet averaged 20 years in age. Vessels in excess of 65 feet in length were, on average, nine years old.

More recently, Keithly and Mounce conducted a study on boats and vessels that utilized the state's inshore waters. They reported that boats 20-30 feet in length were, on average, nine years old. Boats >30-50 feet were, on average, about 16 years old. Boats in excess of 50 feet were 18 years old, on average, with more than one-half of them being built before 1976.

Investment

Sass and Roberts reported that total investment in Louisiana's harvesting sector in 1979 equalled $172 million (1979 dollars) or about $300 million in current dollars. They reported that vessels <66 feet in length appreciated 133% between the time of purchase and spring of 1979, or in 7.2 years. Larger vessels (≥66 feet in length) appreciated 73% over a 5.4 year period. Boat owners, i.e., non-documented vessels, experienced a 12.5% appreciation over an average of 4.5 years.

While the study by Keithly and Mounce is not directly comparable to that by Sass and Roberts or to Roberts and Sass due to a different focus of the two studies, Keithly and Mounce

found no appreciation in values of boats among full-time shrimpers. They reported that full-time shrimpers with boats 20-30 feet in length experienced a 23% decline in boat value between the date of acquisition and spring of 1988, based on initial investment of about $18 thousand. Boats in the >30-50 foot range depreciated eight percent, on average, based on initial investment of $35 thousand. Boats greater than 50 feet in length depreciated almost 15% since date of acquisition, based on initial investment of almost $93 thousand.

Based on 1988 reported market values of inshore boats and vessels, the status of fishermen, and the 1991 distribution of Louisiana's commercial shrimp boats by size, a crude approximation of the value of Louisiana's inshore shrimp fleet can be provided, with a range from about $150 million to $200 million. This figure does not include vessels that shrimp exclusively offshore, which, while relatively few in relation to the total size of Louisiana's shrimp fleet, tend to be the higher valued vessels. But, the figure does include all investment in boats used only part-time in the shrimp fishery. Since vessels/boats constitute the primary input in the harvesting process, the change in value noted between the two studies indicates that the demand for this input has declined in relation to the economic vitality of the industry.

Gear

Trawls and butterfly nets are the primary gears used in Louisiana, though skimmers are reportedly becoming more common. In Table I, a breakdown of commercial shrimping licenses, by gear type, was presented. In 1991, a total of 14,598 residents purchased at least one commercial shrimp gear license. Of this 14,598, a total of 12,452 (85.3%) purchased at least one or more trawl licenses. Another 4,282 residents (29.3%) were issued at least one or more butterfly licenses. A total of 2,136 residents (14.6%) were issued both a trawl and butterfly license.

In their 1987 study of Louisiana's inshore shrimp fishery, Keithly and Mounce reported on gears among full- and part-time shrimpers. Their results are presented in Table V. The exclusive use of trawls by full-time shrimpers in inshore waters increased with boat size. The exclusive use of butterfly nets, on the other hand, declined. More than 25% of full-time shrimpers with boats >30-50 feet used both gears, however, while more than 15% of full-time shrimpers of boats >50 feet reported the use of both gears.

The use of double rigs among full-time shrimpers also increased with boat size in inshore waters, according to Keithly and Mounce (Table VI). Overall, more than 70% of the full-time fishermen with boats in excess of 50 feet in length were equipped to harvest with

two trawls in inside waters in 1987 compared to only four percent of shrimpers with boats 20-30 feet in length. The use of double rigs may now be even higher among all full-time boat classes, due to the fact that only a single trawl was allowed in inside waters in several parishes in 1987. That law has since been repealed. Almost all part-time shrimpers used only a single trawl in inside waters in 1987. Robert and Sass (1980) reported similar findings.

The average reported size of trawls used by full-time shrimpers in inshore waters, as given by Keithly and Mounce, increased with boat size up to the >30-50 foot class and then declined (Table VI). This decline reflects increased use of double rigs by the larger boats.

Harvest Weight

Reported Versus Actual Harvest

For shrimp production to be counted by the National Marine Fisheries Service, it must first pass through an established shrimp dealer. Roberts and Sass (1980), Keithly and Mounce (1990) and Nance et al. (1991) have each reported significant shrimp landings, particularly from inshore waters, that go unreported by NMFS. This is because the catches of many shrimpers, particularly part-time shrimpers, bypass traditional marketing establishments. In a 1978 study of Louisiana's inshore shrimp fishery, Roberts and Sass estimated commercial landings of inshore shrimp catch to be almost 45 million pounds, not including the catch by licensed recreational shrimpers. Landings of shrimp from inshore waters for that year was reported by NMFS to be only 22.6 million pounds and reported landings from all waters (i.e., inshore and offshore) equalled only 66.3 million pounds.

In their 1987 study of Louisiana's inshore shrimp fleet, Keithly and Mounce report that about one-half of commercial licensed shrimpers with boats less than 20 feet in length bypassed shrimp dealers and about 20% of the part-time commercial licensed shrimpers with boats 20-30 feet bypassed dealers. While the authors did not directly estimate inshore catch in total, information they provided in their report can be used to do so. Using a very conservative approach, it was estimated for purposes of the plan that inshore catch exceeded the NMFS reported landings by at least the amount reported by Robert and Sass.

In a 1987 study of the Calcasieu Lake area, Nance et. al.(1991) reported that more than a quarter of landings by the small inshore fleet bypassed established shrimp dealers. These unreported landings included offshore catch.

The implications of these findings are two-fold. First, the state's reported shrimp landings underestimate actual landings; possibly by more than 20%. Second, since most unreported catch represents the harvests of part-time, i.e. inshore shrimpers, the

unreported catch represents a significant number of smaller shrimp. If converted to number of shrimp, unreported catch would represent a significant proportion of the number of shrimp available for harvest. This suggests that caution must be exercised in any analysis of tradeoffs of inshore for offshore catch based on NMFS data.

Landings Versus Catch

When evaluating Louisiana's shrimp production, it is important to differentiate between landings and catch. Discussion of Louisiana's production often focuses on landings. Vessels from throughout the Gulf, however, come to shrimp in Louisiana's waters (including Federal) and often land their catch in ports outside the state. It is therefore important to consider how catch relates to landings.

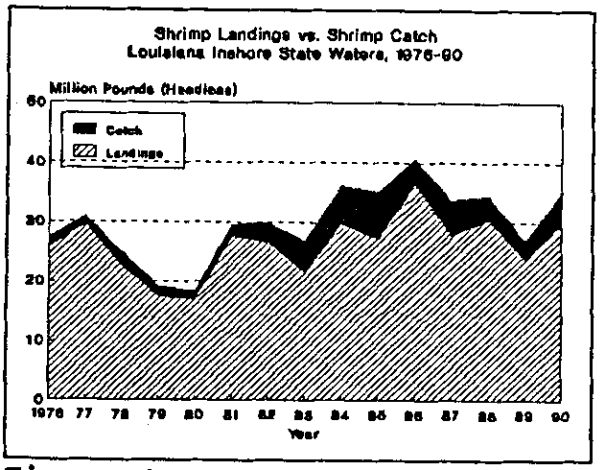


Figure 1

As indicated in Figure 1, catch in Louisiana's inshore waters generally exceeded landings by two to six million pounds annually and averaged slightly less than four million pounds during the 15 year period ending in 1990.

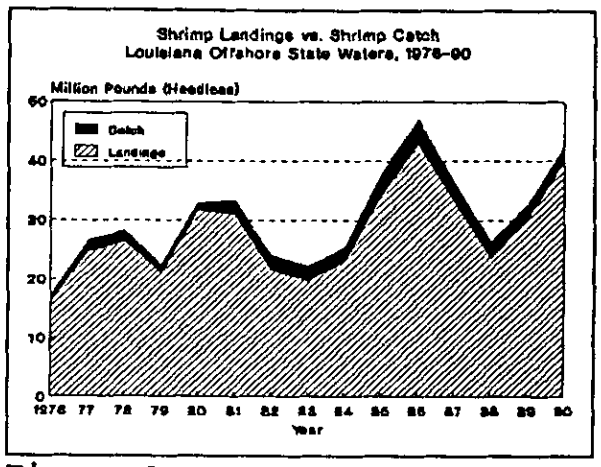


Figure 2

In state offshore waters Figure 2, catch generally exceeded landings by less than three million pounds annually.

In Federal waters, catch generally exceeded landings by at least 50% and often by more than 100% (Figure 3). This large difference reflects participation in Federal waters by vessels that commonly shrimp throughout much of the Gulf Region.

Aggregated Landings

Though marked by considerable year-to-year variation, Louisiana's reported shrimp landings clearly increased during 1970-90 (Table VII, Figure 4). For example, Louisiana's shrimp landings averaged 49 million pounds annually during 1970-74. They increased to 54 million pounds

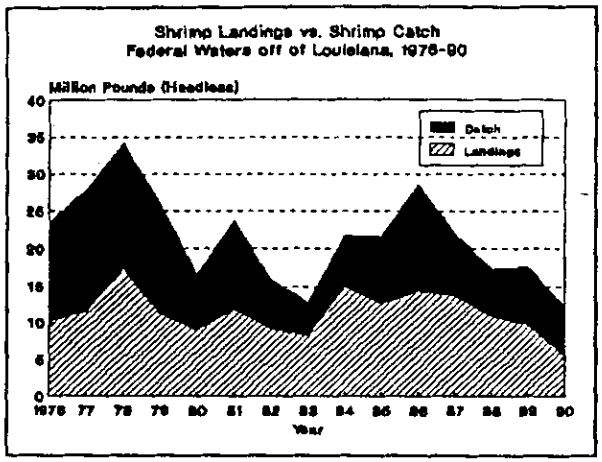


Figure 3

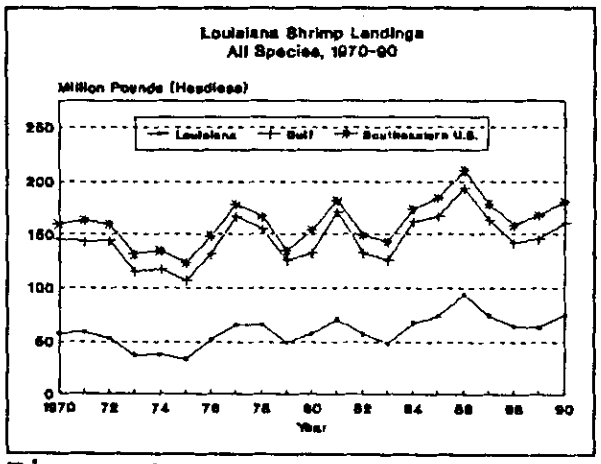


Figure 4

annually in 1975-79, 61 million pounds annually in 1980-84, and 74 million pounds in 1985-89. For the 21 year period ending in 1990, Louisiana's shrimp landings averaged 60 million pounds per year.

In terms of percentage growth, Louisiana's annual reported shrimp landings in 1985-89 represent a 23% increase above annual landings in 1980-84, a 36% increase above annual landings in 1975-79, and about a 50% increase when compared to annual reported landings during the first five years of the 1970s. Overall, landings in seven of the ten years during the 1980s exceeded the long-run, i.e., 21 year, average annual landings of 60 million pounds compared to only two years during the decade of the 1970s.

Shrimp landings in the Gulf Region (coastal states of Florida west coast through Texas) expanded from an average of 134 million headless pounds during 1970-74 to 163 million pounds in 1985-89, a percentage increase of 22%, and equalled 161 million pounds in 1990 (Table VII; Figure 4). Louisiana's 21-year average annual landings of 60 million equalled 41% of the total Gulf Region annual landings of 145 million pounds for the same period.

Because Louisiana's reported shrimp landings increased relative to those reported for the Gulf Region during 1970-90, Louisiana's share of total Gulf Region landings, expressed in pounds, increased substantially during 1970-90. In 1970-74, for instance, Louisiana's contribution to the Gulf Region production averaged 37%. The state's contribution increased to 39% in 1975-79, 42% in 1980-84, 46% in 1985-89, and approached 50% in 1990.

U.S. shrimp production occurs in the Gulf Region and in the South Atlantic Region (coastal states of North Carolina through the Florida east coast). These two regions, referred to as the Southeast, represent all the nation's production of warm-water shrimp. As indicated in

Table VII (Figure 4), South Atlantic shrimp landings are relatively small in relation to those reported in the Gulf Region and averaged 16 million headless pounds annually during 1970-90. Combined South Atlantic and Gulf Region landings, i.e., Southeast (warm-water) shrimp landings, averaged 161 million pounds. Louisiana's contribution to total U.S. warm-water shrimp landings increased from less than a third in 1970-74 to more than 40% in 1985-89 (Table VII; Figure 4)

Browder et al. (1989) hypothesized that Louisiana's increased shrimp production in recent years is the result of deterioration of wetlands in some coastal regions of the state which has provided increased shrimp habitat. To test this hypothesis, they regressed brown and white shrimp catches against the amount of interface area between land and water. They found a positive and significant relation for brown shrimp but not for white shrimp and concluded that increased catches of brown shrimp are related to the amount of interface area. As the amount of interface area peaks and then falls, the catch of shrimp can also be expected to fall.

Shrimp landings in each of the five Gulf Region states, expressed in five-year intervals since 1970 are presented in Table VIII. Louisiana's annual shrimp landings, as indicated, consistently exceeded those reported in any of the other Gulf states (except the first five-year period when Texas landings were higher). Also, the difference between Louisiana's landings and those reported in the other Gulf states increased during the period of study. For example, Louisiana's average annual landings of 49 million pounds in 1970-74 were about six million pounds less than those reported in Texas during the same period. Louisiana's landings exceeded those reported in Texas by more than five million pounds in 1975-79, and almost 10 million pounds in 1980-89. The only state, other than Louisiana, to show significant growth in reported shrimp landings during 1970-90 was Mississippi. The increased landings in Mississippi may, however, reflect, catch from Louisiana's waters.

Landings by Size

Louisiana landings of headless shrimp by size count since 1970 are provided in Table IX. For purposes of discussion, the eight size groups reported in the table are examined on the basis of three aggregated categories: less than 31 headless shrimp to the pound (<31), 31 to 67 headless shrimp to the pound (31-67), and more than 67 headless shrimp to the pound (>67).

<31 Count (Headless)

Louisiana's landings of <31 shrimp to the pound averaged 10 million pounds annually in 1970-74, compared to 8.7 million pounds annually in 1985-89, and 8.3 million pounds in 1990. Throughout the 21 year period of study, 26-30 count shrimp landings and 21-25

count shrimp landings averaged almost 3 million pounds each; 15-20 count shrimp averaged about two million pounds, and < 15 count shrimp averaged less than one-million pounds.

In 1970-74, <31 count shrimp to the headless pound averaged 21% of the state's total shrimp landings by poundage. The share of the state's total landings represented by this category fell to 17% in 1975-79, 14% in 1980-84, and 12% in 1985-89. In 1990, <31 count shrimp to the headless pound fell to less than 12% of the state's shrimp landings in pounds.

Two factors explain the declining share of "large" i.e., <31 count, shrimp landed in Louisiana. (Selection of demarkation points for "large", "medium" and "small" shrimp for this section was made primarily for discussion purposes and is not meant to infer what should be considered "large" "medium", and "small" shrimp). First, landings of the "large" shrimp declined marginally, in absolute terms, during 1970-90. Second, and of greater significance, landings "small", i.e., ≥ 68 count, shrimp increased.

31-67 Count (Headless)

Louisiana's landings of shrimp in the 31-67 count category averaged 16 million headless pounds annually during 1970-90 and were comprised of 5.5 million pounds of 31-40 count shrimp, 3.9 million pounds of 41-50 count shrimp, and 6.4 million pounds of 51-67 count shrimp.

Landings of shrimp in the 31-40 count range increased from an annual average of 5.2 million pounds in 1970-74 to 6.3 million pounds in 1985-89, or 22%. Averaging 3.4 million pounds annually in 1970-74, landings of 41-50 count shrimp increased to about six million pounds annually in 1985-89, or by more than 70%. Landings of 41-50 count shrimp in 1985-89 were, however, abnormally high. Finally, shrimp in the 51-67 count size increased 30% between 1970-74 and 1985-89, from 5.5 million pounds to more than seven million pounds.

Shrimp in the 31-67 count size range represented 30% of the state's total shrimp landings by poundage in 1970-74 and 28% in 1985-89. These figures indicate that the share of the total state's shrimp landings contributed by shrimp in this category remained stable during 1970-90. A further review of the information indicates that there was no significant change in the composition of shrimp by size counts within the 31-67 category during the period of study.

>67 Count (Headless)

"Small" shrimp, i.e., >67 count to the headless pound, comprise a large and growing share of Louisiana's shrimp landings. They averaged 23 million pounds in 1970-74, 28 million pounds in 1975-79, 32 million pounds in 1980-84, 41.5 million pounds in 1985-89, and equalled 50 million pounds in 1990. Since 1975-79, they have averaged well over 50% of the state's total shrimp landings by poundage and have averaged close to 60% since the mid-1980s.

To the extent that "small" shrimp represent the largest proportion of catch among part-time shrimpers, reported landings of shrimp in this size range are likely to be particularly underrepresented. This underrepresentation, furthermore, will be directly influenced by annual and long-term participation changes among the part-time shrimpers.

Though the large landings of "small" shrimp are identified by the information contained in Table IX, the open-ended nature of the >67 count shrimp to the pound can distort additional changes occurring within this category. More specifically, shrimp may still be changing in average size through time but, due to the open-ended nature of the size class, the changes in size will not be accurately reflected. Since 1985, the National Marine Fisheries Service has collected and maintained more detailed data with respect to the >67 count size. Specifically, the >67 category has been subdivided into four additional classifications: 68-80 count, 81-100 count, 101-116 count, and > 116 count. Landings pertaining to these additional count sizes, are presented in Table X.

As indicated, shrimp in excess of 116 to the pound comprised more than 40% of the >67 count category during 1985-90. Shrimp in the 81-100 count range represented another 24.5%, while 68-80 count shrimp represented almost 20%. Overall, there is no apparent trend to decreasing shrimp size in the >67 count category though the short time series of data limits meaningful conclusions with respect to any possible trends.

Size Comparison to Gulf Region

Louisiana's reported shrimp landings by size in relation to reported landings in the Gulf for 1970-90 is given in Table XI, on the basis of five-year intervals. One of the most salient features reflects the large contribution Louisiana makes to Gulf shrimp production in the >67 size count of shrimp, an average of 70% during 1970-90. The contribution, however, appears to have lessened during the period of study from 77% in 1970-74 to 68% in 1985-89. Given Louisiana's increased landings of >67 shrimp to the pound (Table IX), Louisiana's diminishing share of Gulf Region production in this size count is the result of increasing Gulf Region production of "small" shrimp relative to Louisiana's production. As indicated in Table XI. Louisiana contributed all but about seven million pounds of the Gulf Region's >67 count shrimp production in 1970-74. By 1985-89, Gulf production of >67 count shrimp exceeded that reported for Louisiana by almost 20 million pounds. Some of this production may have been harvested in Louisiana and landed in other states.

Louisiana's contribution to Gulf Region production of shrimp in the mid-count size range, i.e. 26-30 count, 31-40 count, 41-50 count, and 51-67 count appears to have increased significantly during 1970-90.

For example, Louisiana's share of 26-30 count gained almost 10 percentage points between 1970-74 and 1985-89, from 19.9 to 29.4. Louisiana's share of 31-40 count, 41-50 count and 51-67 count during the same periods increased by 9%, 12% and 6%, respectively.

Landing Size by Month

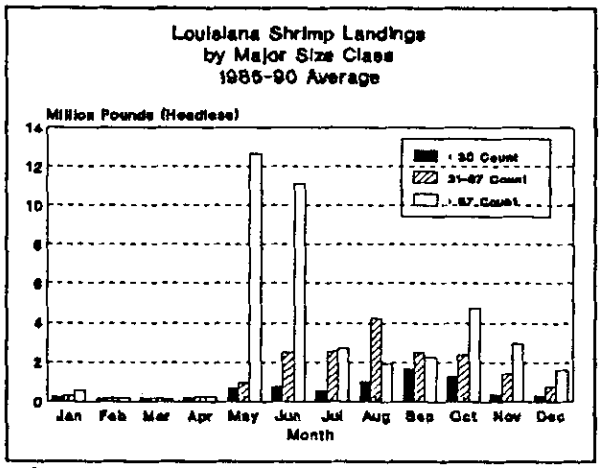


Figure 5

Louisiana's shrimp landings by size and month during 1985-90 are given in Figure 5 . The same information expressed on a percentage basis is given in Figure 6.

As indicated, Louisiana's landings of "small" shrimp, i.e. >67 count to the pound, occurred primarily in the months of May and June. These two months typically accounted for 55%-65% of the state's annual landings of >67 count shrimp. Landings of 31-67 count shrimp ran strongest from June through November, generally peaking in August. About 80%-90% of the 31-67 count Louisiana shrimp landings occurred during this six month period. Landings of <31 count shrimp tended to be more evenly distributed throughout the year, though about 40% of the landings of this size shrimp occurred during the two month period of September and October. The months of May and June accounted for another 15%-20% of landings in this size category.

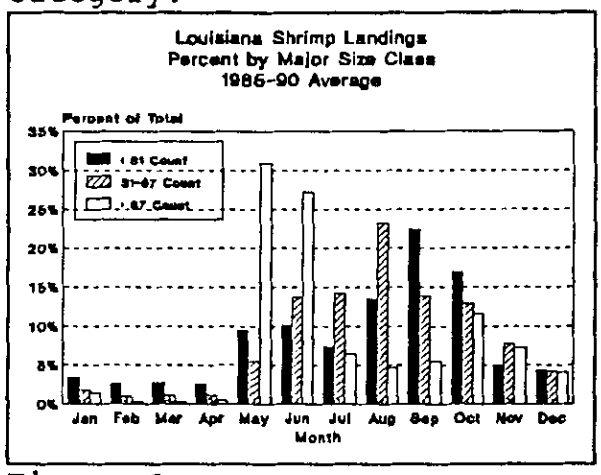


Figure 6

Landings by Species

Louisiana's landings of brown shrimp increased throughout the period of study when evaluated in five-year periods, averaging 24 million headless pounds annually in 1970-74 compared to 35 million headless pounds in 1985-89. As noted, Browder et al. (1989) have suggested that this increase was environmentally induced. White shrimp landings also increased, averaging 23 million pounds in 1970-74 compared to 34 million pounds in 1985-89. (Table XII)

When combined, brown and white shrimp generally represented 93%-96% of Louisiana's total shrimp landings by poundage. Sea bobs, pink shrimp, and rock shrimp represented essentially

all remaining landings. Because both brown and white shrimp landings increased in relatively equal proportions during 1970-90, their individual contributions to total state landings remained essentially unchanged. Brown shrimp contributed 48.7% of the state's shrimp landings, in pounds, during 1970-74 while white shrimp represented 47.3% of the total. In 1985-89, brown shrimp represented 47.6% of the total while white shrimp represented 46.2%.

The size distribution of Louisiana's brown and white shrimp landings, based on three size classifications (<31 ct. headless shrimp to the pound, 31-67 headless shrimp to the pound, and >67 headless shrimp to the pound) is reported in Table XIII. About 70%-80% of Louisiana's reported landings of brown shrimp fell in the >67 count size category, with some exceptions, particularly since the mid 1970s. Another 15%-25% of Louisiana's brown shrimp landings ranged from 31-67 count per pound, again with exceptions. Landings of brown shrimp <31 count to the pound generally represented less than eight percent of the state's total brown shrimp landings, except in the very early years.

The size composition of Louisiana's white shrimp landings varied significantly from one year to the next, as indicated by the information contained in Table XIII. The percentage of pounds falling in the >67 count range commonly varied from 30% to 45% and exceeded 50% in 1989. The percentage of white shrimp falling in the 31-67 count range generally varied from 30%-40%. Landings of white shrimp in the <30 count range generally exceeded 20% and exceeded 30% in seven of the 21 years examined. Six of these seven years were in the 1970's.

Overall, there has been no discernible trend in size composition of Louisiana's brown shrimp landings since the mid 1970's, before which time "large" and "medium" sized shrimp apparently contributed a greater proportion of the state's brown shrimp landings. With respect to white shrimp, however, there does appear to be a decline in the production of "large", i.e., <31 count, shrimp as a percentage of the state's landings of this species. During both 1970-74 and 1975-79, for instance, <31 ct white shrimp landings were less than 25% of the total only once during each of the five year periods. In 1980-84, <31 count white shrimp landings exceeded 25% in only once during the five year period. Since 1985, landings of <31 count white shrimp have not exceeded 22% of the total and in two of the six years were below 20%. Conversely, the >67 count white shrimp exceeded 40% of white shrimp landings two times in each of the first three five-year intervals, given in Table XIII, i.e., 1970-74, 1975-79, and 1980-84. Since 1985, however, >67 count shrimp have not fallen below 40% of the state's landings.

A more detailed breakdown of the >67 count landings, by brown and white shrimp, is presented in Table XIV. Since 1987, about one-third of brown shrimp landings >67 count to the pound also exceeded 116

count to the pound. About 40%-50% of white shrimp landings in excess of 68 count to the pound also exceed 116 count to the pound (the lack of information on white shrimp landings in the 101-116 count range suggests that some of the >116 count shrimp may actually be of 101-116 count to the pound).

Landing Size by Month

Louisiana's average reported brown shrimp landings by month for the 1 period 985-90 are illustrated in Figure

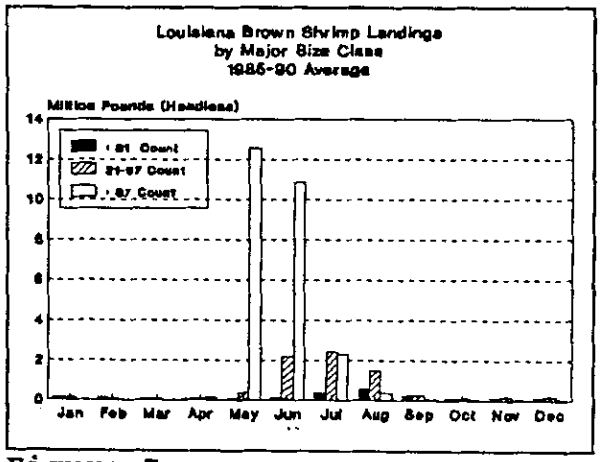
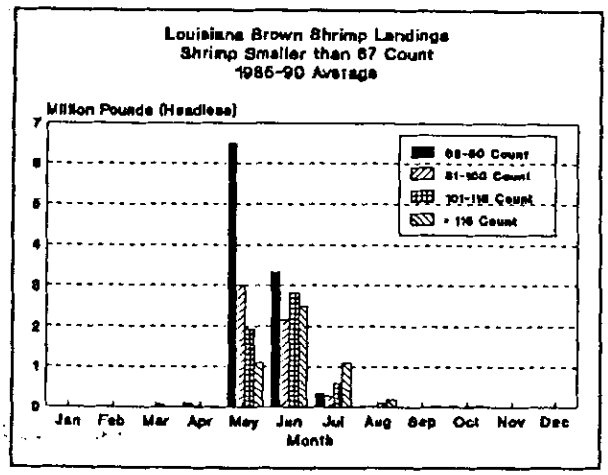


Figure 7

7. The same information on a



percentage basis is given in Figure 8.

Several features merit mentioning. First, the "small", i.e., >67 count brown shrimp fishery is primarily a three month fishery, from May through July. In general, more than 80% of the "small" brown shrimp were landed in the months of May and June, and more than 95% were landed in the three months including July.

Whereas May through July were the primary harvesting months for "small" brown shrimp, "mid-sized", i.e., 31-67 count, were primarily harvested in the months of June, July, and August; with peak landings generally occurring in August. Almost 85%-90% of brown shrimp landings in the 31-67 count range occurred during this three month period.

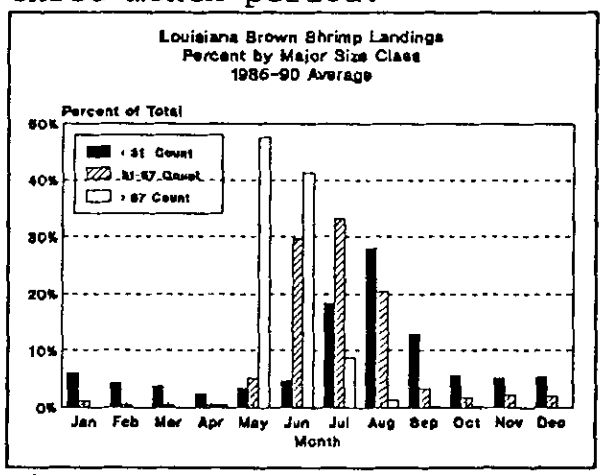


Figure 9

The months of July, August, and September were the primary months associated with the landings of "large", i.e. <31 count to the pound, brown shrimp, with peak production occurring in August.

A detailed breakdown of

monthly landings of >67 count brown shrimp for 1985-90 is provided in Figures 9 and 10. As indicated, harvesting of 68-80 and 81-100 count brown shrimp occurred primarily in May. As the size of shrimp declined past the 81-100 count, June became the predominant month of harvest. About 50% of the ≥116 count brown shrimp (2.5 million pounds) were harvested in June. An additional million pounds were harvested in July.

Louisiana's white shrimp landings by size and month are illustrated in Figure 11 while the same information on a percentage basis is provided in Figure 12.

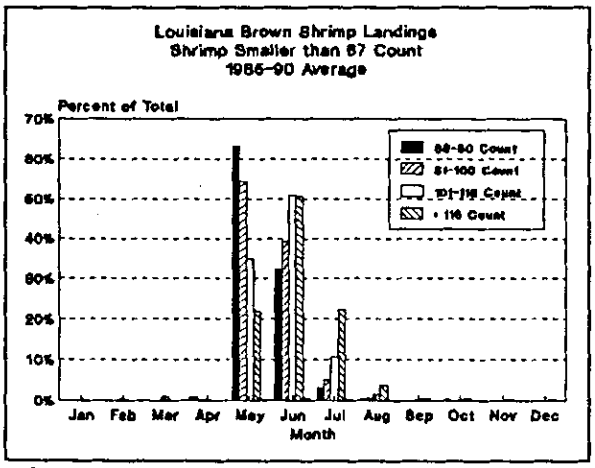


Figure 10

As shown, the "small" white shrimp season generally began in August, peaked in October, and then typically declined through the following May.

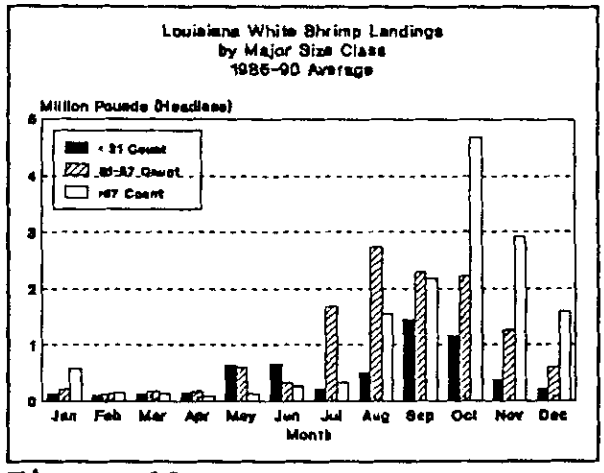


Figure 11

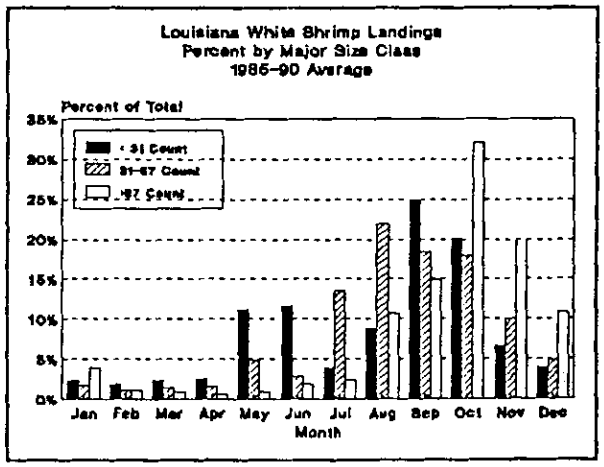


Figure 12

"Mid-size", i.e. 31-67 count, white shrimp landings typically began to expand significantly in August, peaked during the September-November periods, and then declined significantly. The pattern exhibited during 1985-90, however, was significantly different than that observed previously. During this period, "mid-size" white shrimp landings were greatest in August and declined throughout the remainder of the year.

About 40%-45% of

Louisiana's "large", i.e. <31 count white shrimp landings are concentrated in the months of September and October, though the months of May, June, and November also produce sizeable quantities of these shrimp.

Landings by Inshore and Offshore Waters

Louisiana's shrimp fishery can be evaluated on the basis of three separate areas of activities; inshore state (i.e. beach inward), offshore state (i.e. beach out to three miles), and Federal (outside three miles). While the state can institute management measures in its inshore and offshore waters, management measures in Federal waters are under the control of the Federal government.

As indicated in Table XV, shrimp landed in Louisiana are harvested to a large extent in all three areas. Landings of shrimp caught in state inside waters (beach inward) averaged 26 million pounds during 1976-90, or almost 40% of the state's total 66 million pound average annual landings. To the extent that part-time shrimpers are primarily inshore based, inshore landings are likely to be significantly less than actual. The percentage contribution of inshore landings to the total is therefore likely to be significantly greater than reported herein. Overall, shrimp landings from inshore waters appear to be increasing. For example, landings from state inside waters dropped below the long-term average, i.e. 26 million pounds, in only two of the last ten years and only once since 1984.

Louisiana landings of shrimp from state offshore waters averaged 28.4 million pounds annually during 1976-90 and represented 43% of the state's total landings. Since 1985, landings of shrimp from state offshore waters have been well above the long-term average.

Louisiana's landings of shrimp from Federal waters averaged 11.4 million pounds during 1976-90, or 17% of the state's total shrimp landings. Production of 5.5 million pounds in 1990 was by far the lowest reported during the 15 year study period.

Landings by Parish

Table XVI provides information on landings by parish for the 1976-90 period. Terrebonne Parish consistently lead the state in shrimp landings, generally accounting for almost a third of the total. Jefferson Parish, Plaquemines Parish, and Lafourche Parish generally each accounted for 10%-20% of the state's total shrimp landings, followed closely by Vermilion Parish.

Landings by Gear Type

The primary gears used in Louisiana to catch shrimp are the trawl and the butterfly net (wing net). Since 1985, the National Marine Fisheries Service has maintained data on catch by gear type. According to National Marine Fisheries Service estimates, trawls account for more than 90% of Louisiana's shrimp landings

(Table XVII). As previously noted, Louisiana's catch from inshore waters is significantly underreported, largely the result of part-time fishermen bypassing traditional marketing channels. The fact that butterfly nets tend to be used more intensely inshore suggests that landings associated with this gear may be underrepresented.

Catch by Size and Waters

Figure 13 provides information on Louisiana's shrimp catch by size of shrimp in inshore state, offshore state, and Federal waters during 1986-90, while the same information presented on a percentage basis is given in Figure 14. As indicated, the vast majority of

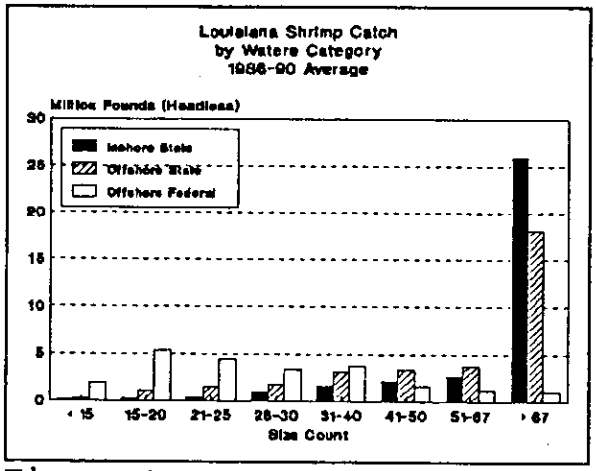


Figure 13

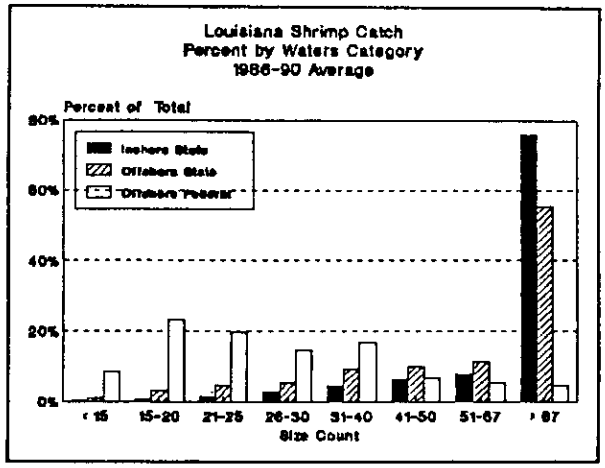


Figure 14

Louisiana's inshore state shrimp catch is composed of "small", i.e. >67 count, shrimp. During 1986-90, almost 80% of the state's inshore catch was comprised of these "small" shrimp (about the same average also reported during 1980-85). About 50%-55% of the state's offshore shrimp catch is also comprised of >67 count shrimp. There are also significant catches of "medium" and "large" shrimp in these waters.

Large catches of all sized shrimp, including the >67 count, are reported from

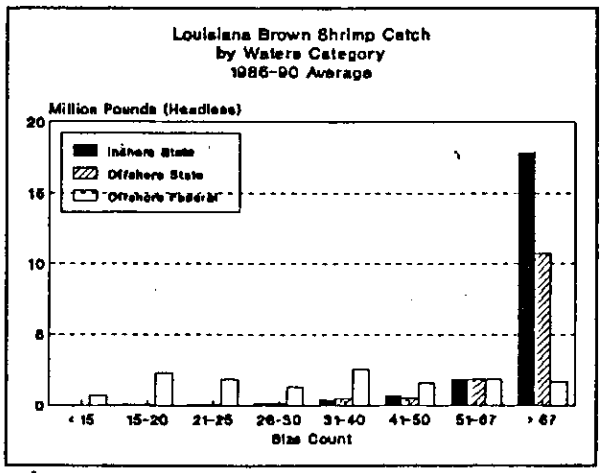


Figure 15

Federal waters.

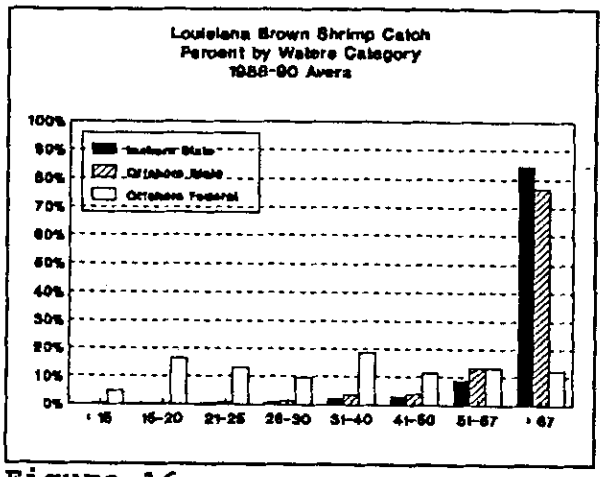


Figure 16

Figures 15 and 16 illustrate catch of brown shrimp (pounds and percentage) in inshore state, offshore state, and Federal waters. Comparable information on white shrimp catches in Louisiana's waters is given in Figures 17 and 18. Catches of brown shrimp in offshore state waters were dominated by the >67 count shrimp which accounted for about 80% of offshore state brown shrimp landings.

White shrimp catch in state offshore waters were less

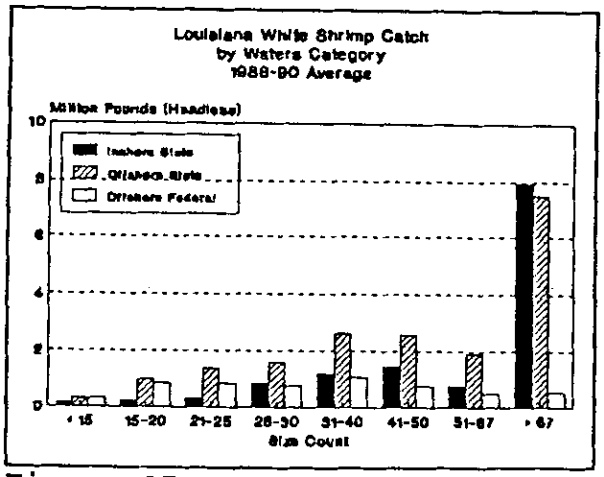


Figure 17

dominated by >67 count, which approximated 35%-40% of total catch in these waters.

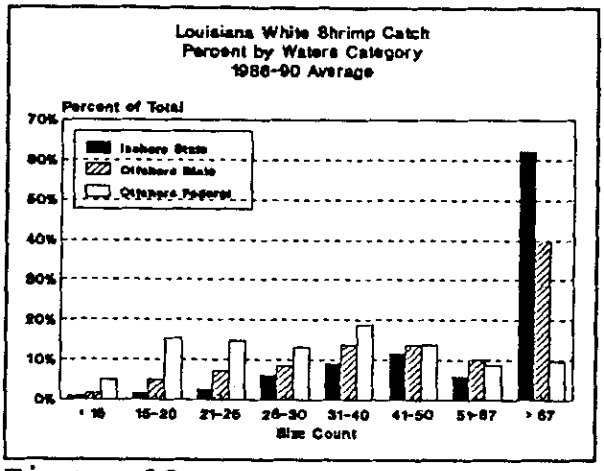


Figure 18

Harvest Effort

Recent Effort

In their 1978 study of Louisiana's vessels, Roberts and Sass reported that vessels less than 50 feet in length shrimped an average of 115 days, 43% of which were spent in inshore waters. Vessels of 51-65 feet in length shrimped 136 days of which 17% were spent in inshore waters. Vessels greater than 65 feet in length shrimped an average of 195 days, none of which were spent inshore. Full-time shrimpers of undocumented craft, according to Roberts and Sass (1980), made an estimated 77 thousand trips in 1978 while part-time shrimpers made an estimated 219 thousand trips. This resulted in a total of

296 thousand trips by undocumented craft. This estimated total exceeded the number of trips reported by NMFS by a large factor. However, trips by part-time shrimpers are not as long as for their full-time counterparts and, hence, effective effort reported by NMFS is not as seriously underestimated.

Keithly and Mounce, in their study of Louisiana's inshore shrimping activities in 1987, provided a detailed analysis of effort among full- and part-time shrimpers. As indicated in Table XVIII, the average number of days engaged in shrimping activities among full-time shrimpers increased proportionately with boat size, even though the number of trips declined past the 20-30 foot boat category. This reflects increased days per trip among the larger boat categories. There was also an increase in days shrimped among part-time shrimpers in relation to boat size.

A detailed breakdown of shrimping effort in inshore and offshore waters throughout the 1987 year by full- and part-time shrimpers was also provided by Keithly and Mounce. This information is given in Table XIX. A rather lengthy discussion regarding interpretation of the table is in order, before attempting to analyze it. The table shows that, in total, 110 full-time shrimpers of boats 20-30 feet in length were surveyed. Of this 110 total, 108 made inshore trips during the brown shrimp season, averaging 30.4 trips each. Total days spent shrimping in inshore waters during the brown shrimp season by this group of fishermen averaged 36.3. All but four (106) full-time shrimpers engaged in inshore shrimping activities during the white shrimp season. They averaged 32.9 trips each at an average of 1.2 days each, yielding an average of 40.9 days of shrimping in inshore waters during the white shrimp season. Ten of the 110 total also fished offshore while inshore waters were open and averaged 23.9 trips each, with the total average number of days spent shrimping offshore while inshore waters were open equalling 43.7. Finally, 14 of the 110 shrimpers reported shrimping offshore when inshore waters were closed to shrimping. This group averaged 14.4 offshore trips during this period, with total days averaging 24.4 each.

Overall, the table indicates that inshore effort among full-time shrimpers, as measured in days fished, increased with boat size up to the largest category of boats (i.e., >50 feet). Days engaged in total inshore shrimping activities by this group, averaging 64.3, was about 25 days less than among full-time shrimpers of boats >30-50 feet in length (89.7 days) and about 10 days fewer, on average, than among shrimpers with boats 20-30 feet in length.

The reason for the decline in inshore days among the largest boat class reflects additional effort offshore by this group of shrimpers, even when inshore waters are open. Fourteen of the 23 full-time shrimpers of boats in excess of 50 feet reported some offshore shrimping while inshore waters

were open, totalling an average of almost 70 days each. By comparison, only 11 of the 65 full-time shrimpers with boats >30-50 feet reported offshore shrimping activities while inshore.

Keithly and Mounce reported that the estimated hours engaged in shrimping activities in Louisiana's inside waters increased with boat size (Table XX). Full-time shrimpers with boats 20-30 feet in length averaged 10.0 hours per day shrimping compared to 10.3 hours among full-time shrimpers with boats 30-50 feet in length, and 11.8 hours among full-time shrimpers with boats greater than 50 feet in length. In all cases, except for the smallest boat category (≤20 feet), hours per day spend shrimping among full-time shrimpers were higher during the brown shrimp season than during the white shrimp season.

Historical Effort

Effort can be measured in a number of ways. One method is based on participation in the fishery (see Table I and II). A more meaningful measure of effort relates to the number of trips taken by the shrimp fleet in any given year. Annual trips related to landings and catch, separated by inshore and offshore waters, are presented in Table XXI for the 1981-90 period.

As indicated, the majority of shrimp trips are taken in Louisiana's inside waters. The reported number of inside trips, associated with either landings or catch, peaked during 1986-88 and fell sharply in the next two years.

Trips associated with landings and catch in inshore waters tend to be very close, generally differing by no more than about five percent. As indicated earlier (Figure 1) catch and landings from inshore waters also tended to be close.

Reported trips in offshore state waters varied from about 30 thousand to 50 thousand annually during 1981-90. Overall, trips associated with landings peaked at just over 53 thousand in 1987 while trips associated with catch peaked at about 57 thousand in the same year. The differences between trips associated with landing and catch in state offshore waters, as indicated in Table XXI, was typically small, averaging less than 10%. The differences between total catch and landings from state offshore waters was also typically small, generally less than four million pounds (Figure 2).

Reported trips in Federal waters associated with landings were less than seven thousand annually during 1981-90, except in 1987 when they exceeded nine thousand. Trips associated with catch, however, exceeded 10 thousand on four occasions during 1981-90 and often exceed the numbers of trips associated with landings by more than 70%. Catch from Federal waters also exceeded landings from these waters by a significant amount (Figure 3).

As noted, the number of trips reported by NMFS underestimated the actual number of trips, especially in inshore waters utilized by part-time shrimpers. Roberts

and Sass (1980) estimated 295 thousand inshore trips by undocumented boats in 1978, compared to 106 thousand inshore trips reported by NMFS for the year. Extrapolation from the data provided by Keithly and Mounce also suggests that the actual number of inshore trips may be more than three times larger than reported by the NMFS in 1987. With the sharp decline in the number of shrimpers in the last couple of years, however, reported trips may now more accurately reflect the actual.

Catch Related to Effort

Catch per trip from Louisiana's inside state, offshore state, and Federal waters for 1981-90 is given in Table XXII. Catch in inside waters generally averaged from about 180 pounds to 250 pounds on a per trip basis. The value of this catch, expressed on a deflated basis, illustrated little change on a long-term basis during 1981-90, though year-to-year fluctuations tended to be large.

Pounds caught per trip in state offshore waters varied from a low of 666 in 1981 to a high of 1,188 in 1985. Catch per trip from offshore waters was significantly higher than that reported in inshore waters, reflecting larger boats and longer trips. The deflated value of the catch ranged from about $1,000 to $1,500 per trip. Overall, the average deflated value per offshore trip during 1986-90 was about 12% below that reported during 1981-85, $1,273 compared to $1,445.

Pounds of shrimp caught per trip in Federal waters averaged 1,853 in 1986-90 compared to 2,437 in 1981-85. The deflated value per trip averaged only $4,634 in 1986-90 compared to $7,332 during 1981-85, a decline of almost 40%.

Further insight with respect to catch per trip can be ascertained from the 1987 study by Keithly and Mounce (1990) of Louisiana's inshore shrimp fleet. However, their results pertain only to that portion of Louisiana's shrimp fleet that shrimped in the state's inshore shrimp fishery during at least a portion of the 1987 year. As such, the results will not include information on larger vessels that shrimped exclusively offshore. This portion of the fleet, while relatively few in number, is expected to exhibit significantly higher catches than that portion of the fleet surveyed by Keithly and Mounce.

As would be expected, catch per trip increased with boat size, according to Keithly and Mounce (Table XXIII). In inside waters, the value of catch per trip increased from $321 among full-time shrimpers of boats 20-30 feet in length to $1,943 among full-time shrimpers of boats ≥50 feet in length. In offshore waters (state and Federal), the value of catch per trip increased from $240 to $2,383.

Dealers

Dealers are generally the first middlemen to take possession of the shrimp. They often provide docking and other services to the fishermen.

In a 1983 study of Louisiana's handlers and processors, Roberts and Pawlyk (1986) found that 75% of the handlers were integrated; either vertically, horizontally or through tacit arrangements. Free docking, credit to vessels, and bonuses were found to be common and were used by dealers to secure supplies. Forty-two percent of the handlers operated an unloading docks or owned shrimping vessels.

Ward (NMFS, pers. comm.) reported that Louisiana had 59 shrimp dealer who purchased from documented craft, i.e. vessels, in 1990, according to statistics maintained by the National Marine Fisheries Services. Six of these dealers were considered large, handling an average of 4.4 million pounds of shrimp each valued at $9.5 million. Another 27 of the dealers were considered medium in size, handling, on average, 1.6 million pounds of shrimp each ($3.2 million in value). The remaining 26 dealers were labeled as "small". They handled an average of 165 thousand pounds each, valued at $274 thousand.

Processing

Quantity

Shrimp processing entails several possible functions. At one extreme, shrimp is merely packed and frozen, upon heading, for eventual sale. At the other extreme, shrimp may be breaded, canned, or dried prior to consumption. Processing activities add value to the harvested product, provide finished goods as desired by consumers, and are an additional source of employment.

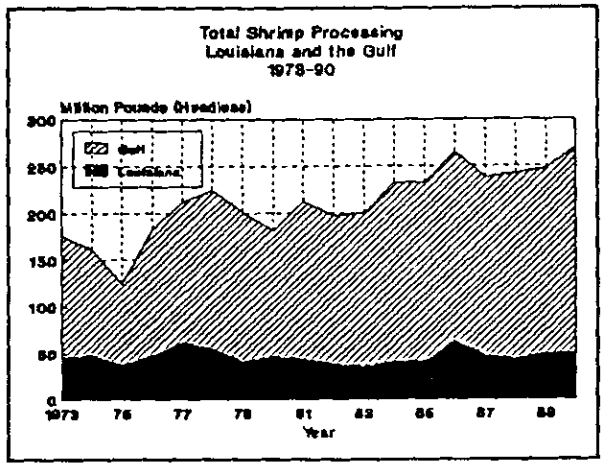


Figure 19

The quantity and value of shrimp processing activities for Louisiana and the Gulf Region are presented for selected time periods during 1973-90 in Table XXIV and Figure 19. Louisiana's shrimp processing activities generally averaged 40-55 million pounds annually during 1973-90 (all processed forms, e.g. peeled, canned, dried, etc. have been converted to a headless shell-on equivalent weight basis) when evaluated on a three-year basis. Year-to-year variations in pounds processed reflect, to a large degree, changes in the state's shrimp landings (Roberts et al. 1991), though processing activities in the long-run have not expanded with shrimp landings.

Pounds of shrimp processed in the Gulf Region, in contrast to that observed in Louisiana, expanded significantly during

1973-90. This is largely the result of increased import usage. While Louisiana does use some imported shrimp in its processing activities, the degree to which imports are utilized is much less than that found in other Gulf states, excluding Texas (Roberts et al. 1992).

Number of Establishments

The number of Louisiana shrimp processing establishments gradually declined during 1973-90, according to unpublished National Marine Fisheries Service statistics, averaging 52 annually in 1973-75 compared to 44 in 1988-90. In the Gulf Region, 134 shrimp processing plants operated annually in 1973-75. By 1988-90, the number had declined almost 15% to an average of 117.

Characteristics

Louisiana's shrimp processors, on average, tended to be smaller than those found in other gulf states, as indicated by the information contained in Table XXV. By weight, Louisiana's companies each processed 850 thousand to 1.1 million pounds of shrimp annually (headless shell-on equivalent weight basis) during 1973-90, on average. When examined in three-year periods, there was little or no definitive growth. Per-establishment processing activities in the Gulf Region expanded from an annual average of 1.2 million pounds in 1973-75 to almost 2.2 million pounds in 1988-90, or by more than 80%. During 1973-75, Louisiana processing activities averaged about 70% of the Gulf Region by poundage, compared to less than 50% during 1988-90.

Louisiana shrimp processing establishments engage in several different forms of shrimp processing activities. Included among these activities are the production of the raw-headless shrimp, peeled shrimp (raw and cooked), breaded shrimp, and "other" shrimp (canned, dried, etc.). Selected statistics pertaining to these individual activities are provided in Table XXVI.

The information in Table XXVI points to the fact that the only component of Louisiana's shrimp processing industry that experienced significant growth during 1973-90 was that of peeling. Peeling activities expanded more than four-fold during the period, from an annual average of 5.5 million pounds in 1973-75 to 24.5 million pounds in 1988-90. This increase occurred without a concurrent increase in the number of establishments processing peeled shrimp, indicating higher productivity per company. In fact, as the information in Table XXVII indicates, processors engaged in peeling activities expanded production from an average or 322 thousand pounds per company in 1973-75 to 1.2 million pounds per company in 1988-90.

While the number of companies processing raw headless shrimp increased from an annual average of 21 in 1973-75 to 28 in 1988-90,

pounds of raw headless shrimp processed did not grow accordingly, indicating a decline in raw headless shrimp production per company (Table XXVII).

Production of "other" shrimp was, in earlier years, an important component of Louisiana's shrimp processing industry, especially the production of canned shrimp. Production, of "other" shrimp products, however, declined steadily during 1973-90, from an annual average of 20.9 million pounds in 1973-75 to 6.2 million pounds in 1988-90. The number of firms processing "other" shrimp products also fell from an average of 25 annually in 1973-75 to only 13 in 1988-90 (Table XXVI). On a per company basis, production of "other" shrimp peaked at about 1.2 million pounds in 1976-78 and fell to 447 thousand pounds in 1988-90 (Table XXVII).

The breading of shrimp has traditionally been a minor component of Louisiana's shrimp processing industry and production of this product form declined throughout the period of analysis. The corresponding number of companies also fell from an average of 11 in 1973-75 to only three in 1988-90.

Gulf Region production of raw headless shrimp generally fell in the 80-100 million pound range with peak production of 117 million pounds in 1986 (Figure 20), coinciding with the state's largest annual harvest. Louisiana's share of Gulf Region raw headless processing activities generally falls in the 15%-25% range.

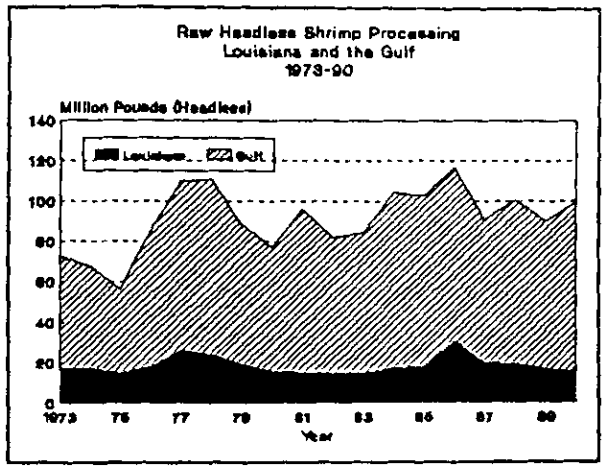


Figure 20

Gulf Region production of peeled shrimp increased from 35 million pounds in 1973 to more than 130 million pounds in 1990 (Figure 21). Louisiana's share of this total has consistently averaged about 20%. With respect to breading activities, Louisiana's contribution to Gulf Region production is negligible, averaging less than one percent in recent years. However, virtually all of the Gulf Region's "other" shrimp processing activities are Louisiana based.

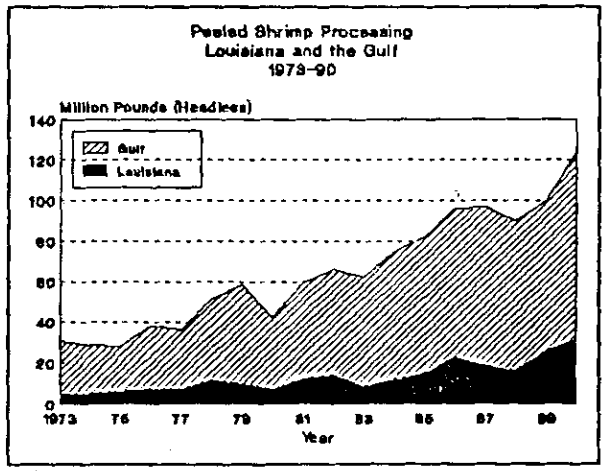


Figure 21

Diversity

An average of 60% of Louisiana's shrimp processors reported producing only one shrimp product on an annual basis during 1988-90, according to unpublished National Marine Fisheries statistics, based on the four categories (raw headless, peeled, breaded, and "other") outlined above. Thirty-two percent reported producing two shrimp products. Only seven percent of Louisiana's shrimp processors reported producing three or four shrimp products during 1988-90. These proportions have remained relatively stable since 1973.

For the most part, Louisiana's shrimp processors deal only in shrimp. Only six of the 44 plants engaged in shrimp processing during 1988-90 reported the processing of other seafood products, according to unpublished National Marine Fisheries Service Statistics, with combined output of less than one-million dollars annually.

Age of Plants

According to unpublished National Marine Fisheries statistics, 18 of the 44 shrimp processing plants operating in Louisiana in 1990 were established before 1975, or 41% of the total . Another six (14%) were established prior to 1980. The remaining 20 plants (45%) have been established since 1980.

Concentration

The largest five processing plants in Louisiana accounted for 50% of the state's shrimp processing activities, by value in 1990, according to National Marine Fisheries Service data. The largest 10 and 20 plants accounted for 72% and 93% of total activities, by value.

Source of Supply

In a 1983 study conducted by Roberts and Pawlyk (1986), the authors found that 61% of shrimp sales by processors was secured from product landed at the processors' docks. Another 34% of processors' supplies were secured from other Louisiana firms and five percent was from out-of-state firms. Imports consisted of less than one percent of total poundage sold. More recent research by Roberts et al. (1992) suggests that imports are increasingly being utilized by Louisiana shrimp processing plants.

Employment

Table XXVIII shows employment (excluding administrative employees) in Louisiana's shrimp processing industry on a monthly basis for the years 1985 through 1990. As indicated, employment generally is highest in June coinciding with the opening of inside waters in the brown shrimp season. Employment then generally declines each succeeding month, with the exception of a slight increase in September/October, before peaking again in the following May. Employment in Louisiana's shrimp processing industry averaged just over one-thousand during 1985-90.

Chapter 3 - Current Management Practices

Regulatory Authority

Legislative Authorization

The Louisiana Legislature has placed all aquatic life within the territory or jurisdiction of the state under the supervision and control of the Louisiana Wildlife and Fisheries Commission (Commission) (36:601)[1] in order to "protect, conserve, and replenish" these resources (56:1(A)). Shrimp, and other aquatic resources are the property of the state and are under the exclusive control of the Commission (56:3(A)), which has "sole authority to establish definite management programs and policies" (56:2). These resources may not be caught, taken, or possessed except as permitted by state law or regulation; even after being taken from state waters in a lawful manner, ownership of aquatic life remains with the state "for the purpose of regulating and controlling the use and disposition thereof" (56:3(B)).

The legislature (56:6(25a)) has given the Commission the duty to promulgate rules and regulations which

> "set seasons, times, places, size limits, quotas, daily take, and possession limits, based upon biological and technical data, for all wildlife and fish. Any such rule or regulation shall have as its objective the sound conservation, preservation, replenishment, and management of that species for maximum continuing social and economic benefit to the state without overfishing that causes short-term or long-term biological damage to any species, and regarding all species of fish, without overfishing that leads to such damage. Any season, time place, size, quota, daily take or possession currently set by law shall be superseded upon promulgation by the commission of new rules and regulations concerning a new species."

The Legislature has set some limits to Commission authority. The Legislature specifically reserves to itself the right to determine the game fish or commercial status of a species (56:6(25a)). Gear types available to the fishery are restricted to those specified by law (56:499(A)). The Commission is required to set seasons based on technical and biological data which indicates that marketable shrimp, in sufficient

quantities, are available for harvest {56:497(A3,A4,A6,A7)}.

Definitions

Statutory definitions {56:8} affecting the management of shrimp include, but are not limited to :

Fish (noun) - all finfish, shellfish, crustacean, frogs, turtles, and other living aquatic resources which have a sport or other economic value.

Shellfish - aquatic invertebrate species having a shell. These species include, but are not limited to, oysters, clams, crayfish, shrimp, crabs, and other mollusks and crustaceans.

Saltwater shrimp - all species of shrimp of commercial or economic value found in the coastal waters of the state and in the Gulf of Mexico contiguous to the Louisiana coast, including the white shrimp or "common saltwater shrimp" (Penaeus setiferus), also called the "lake shrimp"; the brown shrimp (Penaeus aztecus); the pink shrimp (Penaeus duorarum); the "sea bob" (Xiphopeneus kroyeri) also called "six barbes"; the common river shrimp (Macrobranchium ohione); the Delta river shrimp (Macrobranchium acanthurus); and any other shrimp or like species which may be taken from coastal waters or sold through commercial channels.

Trawl - any net, generally funnel-shaped, pulled through the water or along the bottom with otter boards to spread the mouth open while being fished.

Beam trawl - a funnel shaped net the mouth of which is help open by a beam, or by some stationary fixture, while it is being fished.

Butterfly net - a fixed, frame-mounted met, used to fish the near-surface waters, which is suspended from the side or sides of a boat, pilings, floats, rafts, or shore installations.

Lead net or wing net - a panel of netting of any mesh or length, with or without weights and floats attached to one or both sides of the mouth of a cone-shaped net having flues or throats, and set so as to deflect or guide fish toward the mouth of the net.

Skimmer net - a net attached on two sides to a triangular frame and suspended from or attached to the sides of a boat, with one corner attached to the side of the boar and one corner resting on the waterbottom. A ski and one end of the lead line are attached to the corner of the frame that rests on the waterbottom and the other end of the lead line attached to a weight which is suspended from the bow of the boat.

Paratrawling - fishing with a net by affixing a net to or holding a net from two or more vessels so as to pull the net between or behind the vessels.

Cast net - a light circular net of vegetable or synthetic materials, and weighted around its perimeter that is thrown by hand over the water.

Dip net - a net, usually a deep mesh bag of vegetable or synthetic materials, on a fixed frame attached to a handle and held and worked exclusively by hand and by no more than one individual.

Administrative Organization

Statutory law {36:602(B)} has created the Department of Wildlife and Fisheries (Department) to "control and supervise all wildlife of the state, including fish and all other aquatic life" and to "execute the laws enacted for the control and supervision of programs relating to the management, protection, conservation, and replenishment of wildlife, fish, and aquatic life in the state, and the regulation of the shipping of wildlife, fish furs, and skins". The Department is currently composed of the executive office of the secretary, the office of management and finance, the office of wildlife, the office of fisheries.

The Enforcement Division enforces all laws pertaining to the management, protection, and conservation of shrimp; it is located in the executive office of the secretary.

The office of management and finance sells licenses and collects severance taxes.

The office of fisheries is charged with regulation and control of the shrimp fishery and shrimp industry (36:609(C)). It monitors the biological and environmental conditions in the estuarine and near offshore areas, collects catch information from licensed wholesale dealers, performs research to gather new information, and makes recommendations for seasons and other management actions after analysis of available data.

License Fees, Severance Taxes

A severance tax of fifteen cents per barrel of two hundred ten pounds is levied on all saltwater shrimp taken from the waters of the state. Out-of-state shipments other than by common carrier shall be taxed fifty cents per barrel of two hundred ten pounds (56:505).

A commercial fisherman taking fish, including bait species, from state waters or possessing fish in the state must purchase a commercial fisherman's license (56:303). The holder of a commercial fisherman's license may sell his own catch to anyone at any point within the state (56:303.4). Saltwater fish caught or transported by the holder of a commercial fisherman's license are assumed to have been caught in Louisiana waters (56:303.5).

A vessel engaged in commercial fishing or transporting fish must be licensed (56:304).

Gear licenses are available for butterfly nets, seines, trawls, castnets in excess of eight feet six inches in diameter, and "other legal gear" (56:305).

Persons buying, acquiring, or handling fish for resale, including bait species, must purchase a wholesale/retail dealer license (56:306).

Operators and drivers of any form of commercial transport, except common carriers, must purchase a transport license if they do not have either a commercial fisherman's license or a wholesale/retail dealer license (56:307).

Licenses are required to participate in the commercial fishery (56:327(B);
fees (56:303 - 56:308) for these licenses are:

Type	Residents	Nonresidents
Fisherman	55.00	400.00
Vessel	15.00	60.00
Gear		
Butterfly net	25.00	100.00
Seine(s)	25.00	100.00
Each trawl	25.00	100.00
Castnet	25.00	100.00
Other legal gear	25.00	100.00
Whole./Retail	105.00	405.00
Restaurants	30.00	30.00
Transport	30.00	30.00
Common carriers	exempted	exempted

Penalties for Violations

Class 4 and revocation of license after first offense:

Oversized trawls, number of trawls (56:495.1(D,E)). Trawling or butterfly netting in inside waters during closed season (56:495.1(D,E)).

Class 3:

Violation of any section of "Subpart E. Shrimp" for which no specific penalty exists (56:507). Failure to pay severance tax (505(C)).

License and associated reporting violations by commercial fishermen (56:308).

Class 2:

Gear use restrictions in Cameron Parish (56:499.1(C)). Trawling in Lake Maurepas (56:408(C)). Unattended nets (56:322(C7)).

Class 1:

License violations by recreational shrimpers (56:308(A)).

Shrimp taken illegally may be seized (56:507(B), 56:313). Tackle, seines and other nets, trawls and other equipment and devices, including vessels and other means of transport, used in the illegal taking of shrimp may be seized (56:56(6,7), 56:314). Vessels and equipment used with a license obtained by fraud shall be forfeited (56:57.1, 56:338). Vessels involved in illegal activities may be prohibited from obtaining a license or operating in the fishery for two years (56:338(A)). Conviction of Class 1 - Class 7 violations result in revocation of applicable licenses (56:38).

A person who kills, catches, takes, possesses, or injures any fish and aquatic life in violation of law and regulation is liable to the state for the value of each fish and other aquatic life unlawfully killed, caught, taken or possessed (56:40.1). The department has promulgated regulations which assess civil penalties for this action (LR15(10):918 October, 1989). Civil penalties are also imposed for Class 1 violations: first offense, $50; second offense, $100; subsequent offenses, $200 (56:31).

No person shall waste any fish of this state. "Waste" means the harvesting of any fish for commercial purposes which results in the excessive killing of such fish. Any person who wastes fish may be subject to a civil fine by the Department. Rules and regulations have been promulgated to determine what constitutes waste and to assign a fair market value to fish wasted (LR13:1989 (March 1987)). The taking or use of shrimp is exempted from these provisions (56:409.1).

Data Reporting Requirements

Wholesale/retail dealers shall keep records of the quantity and species of fish acquired, the date the fish was acquired, and the name and license number of the commercial fisherman, the wholesale/retail dealer, or the out of state seller from whom the fish was acquired; records shall also be kept of the quantity and species of fish sold, the date the fish was sold, and the name and license number of the person to whom the fish was sold. When sold to the consumer the records shall indicate the quantity, species, and date, and shall state that the fish was sold to the consumer. These records shall be maintained for three years and shall be open to inspection by the Department (56:306.4, 56:345).

Shipments of fish of any species ordinarily used for human consumption made to points outside of the state, other than by common carrier,

shall be registered by the owner or his agent at some port of exit established by the commission and inspected. The shipper shall secure certificates of export from the commission before the shipment can be legally transported to points outside the state (56:307.7).

All vessels transporting shrimp shall keep in writing a manifest of their cargo, a copy of which shall be filed on each trip with the dealer or processor to which delivery is made and a copy sent to the department. The manifest and records are open to inspection by the department. Statements giving the date, quantity, point of origin of each lot, and from whom purchased and to whom delivered shall be sent to the department on forms furnished for the purpose not later than the tenth of the month following date of delivery (56:502).

Severance tax payments to the department shall be accompanied by a statement of the quantity of shrimp fished, purchased, and/or received (56:505(B)).

The names, addresses, and license numbers of commercial fishermen, except for oyster fishermen, shall remain confidential; however the department may make the names and addresses of commercial fishermen available to public or private entities for financial considerations (56:301.4(B)). The Secretary has promulgated rules and regulations controlling the reporting by wholesale/retail dealers and preserving the confidentiality of all fisheries dependant data (LR 18:81) (January 1992), repromulgated as (LR 18:198) (February 1992)).

Reciprocal Agreements

The commission may enter into reciprocal fishing license agreements with the authorities of any other state (56:671).

The commission may enter into reciprocal agreements with the states of Alabama, Arkansas, Mississippi, and Texas pertaining to seasons, bag limits, and all other rules and regulations for the taking or protection of any species or sex of fish or other aquatic life (56:675).

The state of Louisiana has entered into the Gulf States Marine Fisheries Compact. The purpose of this compact is "to promote the better utilization of the fisheries---marine, shell, and anadromous of the seaboard of the Gulf of Mexico---by development of a joint program for the promotion and protection of such fisheries and the prevention of the physical waste of the fisheries from any cause." (56:72) The compact is administrated by a commission which may recommend and coordinate the exercise of police powers of the several states within their respective jurisdiction to promote the preservation of the fisheries and their protection against overfishing, waste, depletion, or any abuse whatsoever, and to assure a continuing yield form the fishery resources of the member states (56:75).

Any restrictions affecting non-resident persons from taking or processing salt water shrimp does not apply to citizens of any state which

grants equal privileges or licenses of this state and which said states have entered into the Gulf States Marine Fisheries Compact (56:496).

TEDs

The Legislature has determined that the imposition of Turtle Exclusion Devices (TEDs) upon Louisiana shrimpers by the Federal Government is "unjustified, inequitable, and unworkable". Therefore the Department is forbidden from enforcing any federal law or regulation which requires any commercial or recreational fisherman to use TEDs in Louisiana waters until certain conditions listed by the Legislature have been met (56:57.2).

Gear Restrictions

Types

Legal gear type and size, as well as mesh size are all regulated by statutory law. Except for bait shrimp, or as provided in underutilized species permits, statutory law provides that saltwater shrimp may be taken only by trawls, butterfly nets, skimmer nets, or cast nets (56:499(A)). Use of a trawl, butterfly net, paupier, night trawl, or beam trawl in inside waters during closed seasons is prohibited (56:497)(B2)).

Number and Length

The number and size of trawls is regulated by statutory law (56:495.1) in the following manner:

1). In inside waters,
one trawl not exceeding 50′ in length along the corkline (66′ along lead line) plus one test trawl, or
two trawls not exceeding 25′ along the corkline (33′ along the lead line) plus one test trawl, or
two trawls not exceeding 25′ along the corkline (33′ along the lead line) plus one test trawl, with the size of the inner sled doors and outer trawl doors specified by statute.

2) In outside waters, no more than four trawls and one test trawl, no length specifications.

3) In Breton and Chandaleur Sounds, two trawls not exceeding 65′ in length (82′ along the lead line) plus one test trawl.

A test trawl is defined by statutory law as not more than 16′ along the corkline (20′ along the lead line or headrope) (56:495.1).

The number and size of wingnets is regulated by statutory law (56:499) in the following manner:

1) Single stationary butterfly nets may not have a net frame which is greater than 22′ measured horizontally or vertically.

2) Double stationary butterfly nets may not have a individual net frame which are greater than 12′ measured horizontally or vertically.

3) Double butterfly nets used on a vessel may not have individual net frames which are greater than 16′ measured horizontally and 12′ measured vertically

Double skimmer nets may not have net frames which are greater than 16' measured horizontally or 12' measured vertically, or with a lead line measuring more than 28' for each net; individual skimmer nets may not be tied together (56:499).

Seines may be up to twelve hundred feet long; bait seines may be up to one hundred feet long.

Mesh Size

Mesh size of any trawl, butterfly net, or skimmer net used to harvest shrimp shall be no less than five-eights of an inch square or one and one-fourth of an inch stretched (56:499(B)). Mesh size of a seine must be one and three-quarter inches square or three and one-half inches stretched. Bait seines must have a mesh of one-quarter inch or less.

Tagging/Marking

Butterfly nets located in the East and West Passes of the Calcasieu River in Grand Bayou must be tagged with the fisherman's name and address, and with the gear license number (56:499.1(B2)).

Day/Night

Trawling for shrimp at night is prohibited in the Cameron Parish sections of Calcasieu Lake, the Black Bayou system, Grand Bayou, and Little Burton's Ditch (56:499.1(A)).

Trawling on White Lake in Cameron and Vermilion Parishes and Grand Lake in Cameron Parish from official sunset to official sunrise is prohibited (56:410).

Navigation

Statutory law provides that operation of butterfly and skimmer nets shall not impede or restrict normal navigation (56:499(B)). Additional specific provisions regarding unmanned platforms or vessels exist for selected waters of Cameron Parish (56:499.1).

Method of Operations

No seine, butterfly net or beam trawl shall be left unattended except those gear which are attached to a wharf or camp (56:322(C7)).

In Chef Menteur Pass, in the Rigolets and in those portions of Lake Pontchartrain and Lake Borgne which are within two miles of the Rigolets or Chef Menteur Pass, a butterfly net or bottom net may be used to take shrimp only when suspended from a fishing boat or vessel which is motor-propelled and underway. No butterfly net or bottom net may be suspended from a piling, float, raft, bridge, or shore installation in the Rigolets or Chef Menteur Pass or in those portions of Lake Pontchartrain or Lake Borgne which are within two miles of the Rigolets or the Chef Menteur Pass. However, in Chef Menteur Pass a single stationary butterfly net may be used by a property owner or lessee, after obtaining a Corps of Engineer permit (46:499.2).

Fishing operations shall be conducted in such a way that nests of fish or the natural hiding places of young fish or shrimp shall not be destroyed. Nets shall not be hauled out

upon the shore in such a way that any illegal fish which may happen to be taken therein cannot be returned to the waters without injury (56:328(A)).

The free passageway of fish shall not be obstructed except by water control structures or dams designed to retain water for conservation purposes. Trawls or butterfly nets which interfere with the free passageway of fish cannot be set within five hundred feet of the mouth or any inlet, pass, water control structure, dam or weir. Free passageway for fish means a minimum passageway opening of five feet in width extending from the surface to the bottom of the water in the deepest portion of the water (56:329).

Season Structure

The open seasons, including special seasons, for all or part of the state waters, are fixed by the Commission (56:497(A2,A6)). Statutory law requires that the Commission fix no less than two open seasons each calendar year for all inside waters by zone (56:497(A7)); no open season may begin on a Sunday (56:497(A8)).

The shrimping waters of the state are divided into two classes: inside and outside waters. The line of demarcation of these classes is specified by law (56:495); typically, it lies along the beach.

In recent years the shrimping waters of the state have been divided into Zones. Zone 1 extends from the Mississippi-Louisiana border to the South Pass of the Mississippi River. Zone 2 extends from the South Pass of the Mississippi River to the western shore of Vermilion Bay. Zone 3 extends from the western shore of Vermilion Bay to the Louisiana-Texas border. Seasons are frequently opened by zones (56:497(A3)) if analysis of data indicates that the populations of shrimp in the different zones vary significantly in size and/or abundance.

Spring Inshore Brown Shrimp

Louisiana's major entrance into penaeid shrimp management was brought about by a request from industry for assistance in the formation of a workable management plan to regulate the brown shrimp fisheries in Louisiana waters (Gaidry and White, 1973). This request resulted from near-failures of the 1957 and 1961 brown shrimp crops. Since the late 60's the department has monitored the size and abundance of juvenile brown shrimp from March-April. The department projects the date that 50% of the brown shrimp will be 100 count/pound or larger and recommends that date to the commission which opens the spring season based on that data and input from the industry.

The inshore waters typically open to the harvest of shrimp in mid-May and harvest proceeds until early July.

Fall Inshore White Shrimp

Until just recently statutory law set the opening of the fall inshore season as the third Monday in August. For the last two years the commission has had the power to open the season. The department has recommended the third Monday in August for both years; analysis of biological data has not indicated a better time to open the season. The season typically remains open until December 20, although it was closed earlier in 1991 because of the presence of small white shrimp on the fishing grounds.

Special Seasons

Spring Pink Shrimp

There have been sporadic openings in the Chandaleur Sound from the late 1970's to present to harvest pink shrimp. These special seasons are held only when pink shrimp are the only commercial shrimp species present. However these special seasons have cause conflicts between user groups, particularly larger vessels vs. smaller vessels, and resident vs. non-resident.

Spring White Shrimp

Occasionally special seasons are opened in Zone 2 and/or Zone 3 to harvest overwintering white shrimp. These seasons are held when the large white shrimp are well separated from the smaller brown shrimp; this usually occurs in mid to late April. These special seasons can aid local economy and fishermen at a time when money is in short supply. Brown shrimp production in Zone III does not normally provide the fishermen with a meaningful revenue source until late June. Their major source of income from April through June is dependent on the beach run of white shrimp which is well known to be somewhat inconsistent during this period. The major drawback to having a special spring white shrimp season is the delay mandated by Title 56 Law that 72-hour notice must be given before opening date. A large portion of the spring white shrimp crop can move to offshore waters once the decision is made to have the season and the 72-hour notice period has elapsed. Since initiation of this management practice, local (Zone III) fishermen expect to have a special season each year. Boat Captains from distant ports complain that they do not have sufficient time to arrive on the fishing grounds for season opening day. Special seasons tend to concentrate a large number of boats in a small area, thereby creating intense competition among fishermen. Unexpected weather conditions during the 72 hour waiting period can trigger a massive egress of shrimp before the opening. There has never been a special spring white shrimp season in Zone I. Spring sampling east of the Mississippi River has not indicated sufficient numbers of overwintering white shrimp to justify the opening of a special season.

Fall Brown Shrimp

Since the 1970's extensions for the brown shrimp

season in Breton and Chandeleur Sounds have been allowed when sufficient populations of large brown shrimp were present. Additionally special extensions for wing netting have been granted for the major passes and the Mississippi River Gulf Outlet in order to maximize the harvest of large brown shrimp leaving Lake Pontchartrain.

Territorial Sea

The Legislature gave the Department authority to regulate outside waters by zone in 1988. Prior to this, outside waters could only be regulated within an established framework which allowed little flexibility, and earlier, simply remained open. Linden (1936) proposed a closure for offshore waters during December, January, and February of each year. This was justified by stating these measures would shift the emphasis of the fishery from small to larger shrimp. This recommendation to avoid growth overfishing developed in 1936 has been made numerous times during these ensuing years by various segments of the scientific community throughout the Gulf coast, but has yet to become reality.

Seabobs

This species has historically been most often harvested between the Mississippi and Atchafalaya Rivers in coastal Louisiana, normally from mid December to mid January. Some sporadic catches may occur any time during the year along the coast, but generally only after August 1. Seabobs are generally considered a supplemental or bonus species, except for the December - January occurrence. This species generally commands a lower price than either brown, white, or pink shrimp due to its small size, and is normally dried and shipped out of state.

Size Limits

Statutory law (56:498) specifies the legal sizes of shrimp in the following manner:
1) There is no limitation as to the count of seabobs, bait shrimp, or shrimp that are documented as having being legally taken in other states or countries and imported into this state.
2) During the open spring season there is no limitation as to the count on any saltwater shrimp taken or in possession.
3) When more than 50% by weight of the saltwater shrimp taken or possessed is sea bobs or brown shrimp, then the maximum allowable amount of undersized white shrimp taken or possessed shall not exceed 10% by weight of the total saltwater shrimp taken or possessed.
4) Except as specified in 2) or 3) above, the possession count on saltwater white shrimp shall average no more than 100 specimens to the pound.

Areas Closed to Commercial Shrimping

Rockefeller Wildlife Refuge
(Title 76, Part 3, Chapter 3, 309)

Trawling on the refuge is prohibited...All commercial fishing is prohibited. Twenty-five pounds of shrimp per boat is allowed during the inside open shrimp season as established by the Louisiana Wildlife and Fisheries Commission annually. Ten pounds of shrimp for bait purposes may be caught during the closed season. Shrimp can be harvested only by cast net on the refuge and only for sport fishing or home consumption use.
(as per R.S.56:6)(LR15:100;February, 1989)

Marsh Island Wildlife Refuge
(Title 76, Part 3, Chapter 3, 310)

Trawling on the refuge is prohibited. All commercial fishing and use of any commercial fishing gear on the refuge is prohibited. Twenty-five pounds of shrimp (heads on) per boat or vehicle per day is allowed during the inside open shrimp season as established by the Louisiana Wildlife and Fisheries Commission. Ten pounds of shrimp (heads on) for bait purposes may be caught during the closed season. Shrimp may be harvested only by cast net on the refuge and only for sport fishing or home consumption use. (LR15:101;February, 1989)

Pointe-au-Chien Wildlife Management Area
(Title 76, Part 3, Chapter 3, 312)

Commercial fishing is prohibited except in Cut Off Canal and Wonder Lake. Recreational shrimpers may take shrimp by the use of cast nets only. During the inside open shrimp season the taking of 25 pounds per boat per day (heads on) are permitted. Size count to conform with open season requirements. During the inside closed season 10 pounds per boat per day, heads on may be taken for bait. (LR15:101;February, 1989)

Salvador Wildlife Management Area
(Title 76, Part 3, Chapter 3, 313)

Commercial fishing is prohibited. Recreational shrimpers may take shrimp by the use of cast nets only. During the inside open shrimp season the taking of 25 pounds per boat per day (heads on) are permitted. Size count to conform with open season requirements. During the inside closed season 10 pounds per boat per day, heads on may be taken for bait. (LR15:101;February, 1989)

Lake Charles, Moss Lake and Prien Lake
(Title 76, Part 7, Chapter 3, 301)

The waters of Lake Charles, Moss Lake and Prien Lake are closed to all commercial fishing whether by means of seines, trammel, gill and butterfly nets, and all trawls over sixteen feet; however, the lakes will remain open to the use of sixteen foot trawls in season.
(as per R.S.56:22)(

LR7:51;February 1981)

Bayou Judge Perez
(Title 76, Part 7, Chapter 3, 303)

The waters of Bayou Judge Perez from its entrance into Lake Judge Perez to Devil's Bayou, a distance of approximately one mile, located in the Plaquemines Parish are closed to butterfly nets and trawls. (as per R.S.56:493(A))(LR2:219;July 1976)

Grand Isle Waters
(Title 76, Part 7, Chapter 3, 305)

The waters on the south side of Grand Isle from Caminada Pass to Barataria Pass, in Jefferson Parish, from the southeast side of Caminada Bridge to the northwest side of Barataria Pass at Fort Livingston, extending from the beach side of Grand Isle to a distance of five hundred feet beyond the shoreline into the Gulf of Mexico from Grand Isle are closed to the taking of fish with salt water netting, trawls, and seines of any type from May 1 to September 15, both dates inclusive. (as per R.S.56:6)(LR5:329;October 1979)

Cypremort Point State Park
(Title 76, Part 7, Chapter 3, 306)

The use of gill nets, seines and trawls from the Cove immediately adjacent to Cypremort Point State Park, St. Mary and Iberia Parishes, LA is prohibited. The area to be closed shall be landward of a line from the point commonly known as Blue Point to the point of land commonly known as Cypremort Point, including all waters therein to the existing shoreline. (as per R.S.56:6(10) and R.S.322(c)(6)) (LR12:843;December 1987)

Calcasieu Lake, Sabine Lake
(Title 76, Part 7, Chapter 3, 333)

The areas within a one quarter mile radius on the lake side only of the Lambert, Grand Bayou, Mangrove, and Peconi water control structures (otherwise identified as structures no. 5, 1, 8 and 4 respectively), and the area within a one eighth mile radius on the lake side only of the water control structure on No Name Bayou, all within the Calcasieu Lake system; the area within a one quarter mile radius on the lake side only of the mouths of West Cove Bayou, West Cove Canal and the Sabine Refuge Headquarters Canal where they empty into Calcasieu Lake; and the area within a one quarter mile radius on the lake side only of the mouths of Three Bayous and Willow Bayou where they empty into Sabine Lake, are fish sanctuaries and closed zones, and that all netting of fish by any means or method, including but not limited to trawls, butterfly nets, gill nets, seines, or trammel nets, is hereby prohibited, with the exception of hand cast nets, crab traps and crab drop nets. (as per R.S. 56:315) LR16:421 (May, 1990).

Lake Maurepas

Trawling in Lake Maurepas is prohibited (56:408)

Lake Des Allemands

Trawling north of the U.S. Highway 90 Bridge at Des Allemands, and in Lake Des Allemands, its streams and tributaries, is prohibited (56:405(B)).

Lake Borgne

Seines are prohibited near Half Moon Island and Grassy Island (56:407)

Chandeleur Sound

Seines are prohibited in Chandaleur Sound (56:406)

Lake Pontchartrain Sanctuary

Acts 1954, No. 476 prohibited trawling in a portion of Lake Pontchartrain.

Paratrawling in Canals

No person shall paratrawl in any canal which is part of the waters of the state (56:410.1).

Recreational Shrimping

A recreational fisherman must purchase a basic recreational fishing license (residents, $5.50) (56:302.1(A.1) to use a castnet (radius not to exceed eight and one-half feet) (56:302(A)). In order to fish in the saltwater areas of the state he must also purchase a saltwater license (residents, $5.50) (56:302.1(C.1)). To use a trawl (length not exceeding sixteen feet) the fisherman must purchase a $25 gear license (56:302.3(B)); recreational shrimpers are not allowed to use a seine (56:302.3(D)). Recreational fishermen wishing to take fish for sale or in excess of any limitation as to size, length, or quantity for recreational fishermen must purchase a commercial fisherman's license, commercial gear license, and vessel license if applicable; this includes recreational fishermen wishing to use commercial gear to take shrimp for other than commercial purposes (ie. home consumption or bait) (56:302(C)). Basic and saltwater license exemptions exist for residents older than 60 years or younger than 16; disabled veterans; persons who are blind, paraplegic, or multiple amputees; and members of the armed forces who are on active duty (56:302.2).

A recreational fisherman may, in open waters in open season, use a trawl not to exceed 16' and may take no more than 100 pounds of shrimp (heads on), in the aggregate, at any one time per day to each boat, regardless of the number of persons thereon, provided the shrimp taken are used for bait or for the fisherman's own consumption and are not sold, traded, or otherwise permitted to enter into commerce. (56:499.2(A))

A recreational fisherman may, in open waters, in open season, use a castnet not to exceed 6' in radius and may take no more than 50 pounds of shrimp, in the aggregate, at any one time per day to each

boat, regardless of the number of persons thereon, provided the shrimp taken are used for bait or for the fisherman's own consumption and are not sold, traded, or otherwise permitted to enter into commerce. (56:499.2(B))

Bait Shrimp

Bait shrimp may be taken in state waters during the closed season; legal gear for this activity as specified by statutory law are cast nets, manually operated dip nets less than three feet in diameter, bait traps , manually operated seines less than one hundred feet long with mesh size of one-fourth inch or less, and other devices approved by the commission. (56:497(B.2), 56:323(A))

Special bait dealers permits are given to take live bait during the closed season between the spring and fall shrimp seasons (56:497(C)). The special bait dealer's permit is intended solely for the benefit of the recreational fishing public which desires to use live shrimp as bait during the closed season between the spring and fall shrimp season. Its purpose is to allow the uninterrupted operation of those commercial establishments which sell live bait shrimp to the fishing public during the spring and fall shrimp season. The permit is not intended for the direct use of recreational fishermen, charter boats, commercial fishermen who sell dead shrimp, or for any other entity which may wish to catch shrimp for their own use during the closed season. (Title 76, Chapter 3, Section 329; LR3:210, (April 1977), amended LR15:867 (October 1989)) .

Mariculture

"Recognizing the value to the economy of the state of Louisiana of developing a mariculture industry in the coastal zone, and recognizing that a mariculture industry has the potential of employing thousands of Louisiana citizens, thereby decreasing unemployment and the burden that unemployment places on the state fisc, and recognizing that mariculture is compatible with the state's policy for managing and enhancing the renewable resources of the coastal zone, and recognizing that mariculture is compatible with the social and cultural heritage of the coastal area, and that mariculture will provide economic incentive for landowners to undertake management programs that will prevent erosion and deterioration of the invaluable coastal wetlands, it is the policy and purpose of the legislature to provide every method of encouragement and assistance to the wetland owner of the state of Louisiana, to protect the culture and heritage that is unique to Louisiana, to prevent unemployment of Louisiana citizens, to assure adequate food for Louisiana, and to provide for economic stability for those areas of Louisiana so dependent upon the seafood

industry. Recognizing that mariculture represents a technique for stocking our coastal waters in a manner that may significantly increase the total volume and improve the quality of the annual fish harvest in the area of both commercial and sports fisheries and that this may be the only viable approach for replenishing the stressed and diminishing natural fisheries stock in Louisiana coastal waters; and that without mariculture Louisiana citizens may realize the continuing decline in the quantity and quality of the fisheries resources and related economic consequences of this decline. To that end, the legislature of Louisiana shall foster and encourage the experimental implementation of maricultural practices within duly authorized and permitted marsh management systems within the coastal zone of the state of Louisiana" (56:579.1(A)).

Chapter 4 - Bioprofile of the Major Species

General Features

The general life cycles of brown, white, and pink shrimp are similar. Adults spawn in the Gulf. Fertile eggs hatch into planktonic free swimming larvae, and the larvae pass through a series of molts into the postlarval stage. During the postlarval stage, the tiny shrimp (usually less than 15 mm) enter estuaries and become bottom feeders.

Within the estuary, postlarval and juvenile shrimp feed mainly at the marsh-water interface, in flooded marshes, in submerged grass beds, and in open water bottom areas rich in food supply. Growth and survival in the estuary are largely dependent upon local salinity and water temperature regimes as well as the abundance of predators and food. As they grow larger, the juvenile shrimp shift to deeper waters and may become more carnivorous. At a variable size (70 to 120 mm) they emigrate to the Gulf. This emigration is a function of size, tide, water temperature, and cold fronts. Growth continues at a rapid rate in the Gulf under optimum temperatures, though it declines as the adults approach their maximum size. Spawning begins before the shrimp are 12 months old or shortly thereafter and is likely repetitive. Shrimp may live for several years.

Major differences in the life cycles of the brown, white, and pink shrimp are due to shifts in the time and space at which various life stages reach their maximum abundance. These shifts may allow the species to avoid direct resource competition even when they predominate in the same general geographical area. In areas where shrimp co-occur, management has built its harvest strategies to take advantage of these shifts. For example, the Louisiana estuaries remain closed in early spring in order to protect newly recruited juvenile brown shrimp from indiscriminate fishing for larger whites. Further, the inshore Louisiana brown shrimp season is closed when appreciable numbers of newly recruited juvenile white shrimp

appear in experimental trawls.

The Louisiana white shrimp fishery used to be the center of production of the Gulf and South Atlantic shrimp fishery from the late 1920s through the 1940s. Beginning in 1948 and continuing through 1962, the Louisiana white shrimp fishery went into a dramatic state of decline. At the same time brown shrimp, which had only accounted for 2 to 3% of the catch, blossomed; and commercial concentrations of pink shrimp were discovered off Florida.

Reasons for this decline in the white shrimp catch and the apparent species shift towards brown shrimp are not well understood but may relate to natural cycles, spraying of DDT on the nearby sugar cane fields, oil and gas activity in the coastal zone, man-made alterations of estuarine habitats and salinities, or fishing.

The major threat to the continuance of the present fishery continues to be loss of estuarine habitat. Whereas the largely artificial and man-induced current process of marsh loss may provide a temporary stimulus to shrimp productivity (e.g., as through increases in edge effect, flooded marshes, and food supply), once the marshes are lost shrimp production may precipitously decline.

A new threat to the fishery is the possibility of privatization of public water bottoms.

There are three biological factors which appear to contribute to the dominance of these resources in the current system:

1) The migration of the life stages through several environments allows greater access to different resources and appears to reduce intraspecies resource competition.

2) The omnivore, opportunistic-omnivore food habits of juveniles and subadults in the estuary provide access to an organically rich, widely-based food supply capable of supporting large populations.

3) Rapid growth rates under favorable conditions, high fecundity, and repeated spawning results in a vigorous population which has been able to sustain current, heavy levels of exploitation.

Differences Among the Major Species

There are at least two important differences among the dominant species. First, mating in brown and pink shrimp is not timed to spawning. Mating occurs during the female's molting cycle, as in blue crabs, and begins when the female is immature. After mating, female brown and pink shrimp carry the male's sperm sac (the spermatophore) in a special chamber on the ventral side of their cephalothorax (the area commonly called "the head"). Later, when females spawn, the eggs are fertilized with this stored sperm.

Female white shrimp differ from brown and pink shrimp in that they do not have the special chamber for retaining the male's sperm. Additionally in white shrimp mating is not linked to molting. Rather

white shrimp may have a repetitive mating cycle during the spawning season which appears to be closely tied to the onset of sunset. As sunset approaches, a third to a half of the mature females may begin to bring some of their eggs to a mature state and mate. Once they have mated, the sperm sac begins to break down. During the night the mated females apparently spawn. This cycle may be repeated by an individual female white shrimp every 2 to 3 days.

The second difference is between white and brown shrimp and relates to estuarine habitat use and burrowing. Juvenile brown shrimp make much more use of the flooded marsh surface than do juvenile white shrimp. Brown shrimp select for this habitat and it provides them a good degree of protection from those predators which depend on sight, though it does not appear to provide protection from more effective predators like red drum (Sciaenops ocellatus) and spotted seatrout (Cynoscion nebulosus). Brown shrimp burrow deeper than white shrimp and are more likely to burrow in less turbid water. Again, this provides protection from some predators, but not others such as the southern flounder (Paralichthys lethostigma). White shrimp, on the other hand, will use the flooded marsh surface just as readily as they will use open water bottoms where concentrations of food are available.

General Features of the Minor Species

The other two shrimp species exploited off Louisiana are seabobs and, to a small degree, royal red shrimp. These species are not estuarine-dependant but apparently spend their life cycles within the open waters of the Gulf. Seabob shrimp are mainly harvested, often with white shrimp, October through December when they migrate towards the Gulf beaches from deeper water, seemingly in response to advancing cold fronts. Royal red shrimp are the most different from the shrimp considered here in that they are harvested from depths of 100 to 300 fathoms, and exist in a relatively stable environment.

Distribution

Brown Shrimp

Penaeus aztecus aztecus is the subspecies of Penaeus aztecus which supports the Louisiana brown shrimp harvest. It has a discontinuous range which extends from Martha's Vineyard, Massachusetts, around the Florida Peninsula to the northwest Sanibel grounds off western Florida. The range is broken from this point to Appalachicola Bay, Florida, where brown shrimp appear again and continue along the northern and western Gulf of Mexico coasts down to the northwestern coast of the Yucatan Peninsula (Perez Farfante 1969).

Near the start of the fishery for brown shrimp the peak of abundance of large adult brown shrimp in U.S. Gulf waters was off the mouth of the

Mississippi River in 32 to 34 fm (Springer 1952). In the current Gulf fishery, the center of abundance of adult brown shrimp is along the Texas coast and in the Campeche Gulf near Ciudad del Carmen (Perez Farfante 1969). The reason for this apparent shift in abundance of adult brown shrimp in U.S. waters from the Louisiana to the Texas coast has not been studied, but it would be expected given the current management regimes of the various Gulf states.

By depth, greatest densities of adult P. a. aztecus currently occur between 15-30 fm but adults are abundant out to 60 fm, and have been reported as deep as 90 fm (Perez Farfante 1969).

Penaeus aztecus aztecus differs from its southern subspecies, Penaeus aztecus subtilius (the Type B. Penaeus aztecus of Burkenroad 1939) in a number of morphological features which suggest a degree of geographic reproductive isolation of the two subspecies. Most noticeably, the central keel or ridge on the head (median sulcus of the cephalothorax) is longer and deeper and the two lateral keels on either side of the central keel (adnostral sulcus) is longer and broader on P. a. aztecus as compared to P. a. subtilius (Perez Farfante 1969).

The range of Penaeus aztecus subtilius is discontinuous from that of Penaeus aztecus aztecus along the northeastern and eastern coast of the Yucatan Peninsula. Its distribution begins off the coast of Honduras and along the Caribbean and northeast Atlantic coast of South America to near the Tropic of Cancer. It also occurs in the Caribbean from Cuba through the Lesser Antilles. Over much of this range its abundance may not be great, and may be discontinuous, however it is very abundant in the southern portion of its range. It frequents waters out to 105 fm (Perez Farfante 1969).

White Shrimp

White shrimp, Penaeus setiferus, have a discontinuous distribution along the North American Atlantic and Gulf of Mexico coast. They range from Fire Island, New York to Saint Lucie Inlet, on the east coast of Florida. From here they are absent on the Florida coast until Appalachicola Bay, west Florida, where they appear again and extend along the Gulf Coast to the Yucatan Peninsula, Mexico. In the Gulf there are two centers of abundance: one off Louisiana and the other near Ciudad Campeche. The Atlantic center of abundance is less than that of the Gulf and occurs off Georgia and northeast Florida (Perez Farfante 1969).

By depth, the distribution of white shrimp is more localized than any Penaeus in that large concentrations are found only within 20 fathoms and the deepest reported occurrence is 43 fathoms (Springer and Bullis 1952). The Atlantic-Gulf separation is believed to have occurred during the Pleistocene with the consolidation of the Florida peninsula. Despite the long reproductive separation, there are no morphological

differences noted between the white shrimp of the two distributions (Perez-Farfante 1969).

Morphologically, Penaeus setiferus most closely resembles Penaeus schmitti, a white shrimp of the same suborder which is found in the Antilles, Central and South America, although the external reproductive parts differ morphologically (Perez Farfante 1969). Mariculturists have demonstrated that these two shrimp can produce a limited number of viable offspring when females from either species are artificially inseminated with sperm of the other (Bray et al. 1990).

Pink Shrimp

Penaeus duorarum duorarum is the subspecies which supports the pink shrimp fishery in the Gulf of Mexico. It ranges from the lower Chesapeake Bay southward to the Florida Keys and continues without interruption along the coast of the Gulf of Mexico to the northeastern edge of the Yucatan Peninsula. It also occurs off Bermuda. Its abundance is greatest off southwestern Florida and in the southeastern portion of the Gulf of Campeche (Perez Farfante 1969).

The greatest concentrations of adults are found between 6 and 20 fm, though it is abundant at 35 fm in locations. Its depth range extends to 180 fm (Perez Farfante 1969).

Penaeus duorarum duorarum is the Form A Penaeus duorarum of Burkenroad (1939). It is distinguished from Burkenroad's Form B Penaeus duorarum (now Penaeus duorarum notialis) by the keel or ridge on the last segment of the tail (dorsolateral sulcus of the sixth abdominal somite). In P. d. duorarum this keel is statistically narrower (measured as the ratio of the height of the keel to its width) than in P. d. notialis.

The range of Penaeus duorarum notialis begins at the southern end of the range of Penaeus duorarum duorarum. It appears in the Gulf of Honduras and continues south along the Caribbean coasts of Central and South America and (with a possible brief interruption) along the Atlantic Coast of Brazil to near the Tropic of Capricorn. P. d. notialis also ranges along the northern Caribbean Islands from Cuba to the Virgin Islands and occurs along a section of the African Atlantic coast.

P. d. notialis normally occurs within 60 to 65 fm, but has been recorded as deep as 400 fm, in association with royal red shrimp and other deep water penaeids (Perez Farfante 1969).

Population Genetics

Lester (1979) studied the population genetics of white, brown, and pink shrimp in the Gulf of Mexico to determine whether each species comprised a single, species-specific gene pool. He collected white and brown shrimp from Mobile Bay, Alabama; Barataria Bay, Louisiana; Galveston Bay,

Texas; and the Gulf of Campeche. Pink shrimp were collected from the lower Laguna Madre, Texas; Galveston Bay, Texas; Tampa Bay, Florida; and Key West, Florida. He found a lack of genetic differentiation within these three shrimp and concluded that each species has a single gene pool in the Gulf of Mexico.

Lester (1979) notes that these three shrimp species have two dispersal phases within their life cycles which contribute to genetic continuity: (1) the passive drift of the larvae in the offshore currents and (2) the offshore migrations of the adults. Because these life history features facilitate gene flow, Lester cautions that any manipulation of the gene pool within a region of the Gulf will have Gulf-wide impacts.

In this regard, recent advances in artificial hybridization of white shrimp should be viewed with extreme concern by management. Female white shrimp have been successfully artificially inseminated with sperm from two closely related species: P. stylirostris (Lawrence et al. 1984) and P. schmitti (Bray et al. 1990). While hatch rates were less than 1% in both studies, 33% of the successful crosses in the first study resulted in some viable nauplii; in the second study, 46% of the nauplii survived to the postlarval stage. Since "genetic manipulation of domestic stocks appears to be a strong likelihood in the near future" (Bray et al. 1990, p. 282) for aquaculture purposes, prudent management should now move to protect these highly stressed wild stocks from the thoughtless introduction of these artificial products.

Taxonomic Distinction

The presence of spines on the keel (dorsal carina) of the sixth tail (abdominal) segment distinguishes brown and pink postlarval shrimp from white postlarval shrimp, which lack spines on the keel (Ringo and Zamora 1968).

Juvenile and adult white shrimp are easily distinguished from brown and pink shrimp. Brown and pink shrimp (members of the family of "grooved shrimp") have a groove on either side of the dorsal keel of the head (cephalothorax), while white shrimp do not.

Generally adult pink shrimp can be distinguished from adult brown shrimp by the presence of a dark, roundish spot on either side of the third and the fourth segment of the tail (abdomen). However, Perez Farfante warns that the presence/absence of this spot can not be used with certainty to distinguish brown and pink shrimp. Rather she provides a series of comparative measurements of body parts which can be used in their taxonomic differentiation (Perez Farfante 1969, pp. 510-512).

Similarly, juvenile brown and pink shrimp are not easily distinguished, though Perez Farfante (1969, p. 512) does provide specific guidance.

Early Life Cycle of the Major Species

Brown Shrimp

With the exception of the recent interest in estuarine recruitment mechanisms of Rogers et al. (1991), much less is published on the reproductive cycle and early life history features of brown shrimp than on white shrimp.

Renfro and Brusher (1964, 1965) examined the ovarian development of white and brown shrimp along the Louisiana and Texas coast. While they do not discuss the results of their histological analyses in detail, the pattern discussed for both species is very similar to that outlined in detail for white shrimp by King (1948).

Based on the percentage of ripe female brown shrimp in their samples, Renfro and Brusher (1964, 1965) concluded that brown shrimp (females generally longer than 160 mm) spawned in Gulf waters of greater than 10 fathoms from spring to early summer and continuously at depths of 25 to 60 fathoms. Two peaks were noted, a major peak from September to November followed by a minor peak from April to June (Renfro and Brusher 1964, 1965).

A February to March spawning peak was proposed by Gunter (1950) and Kutkuhn (1962) based on juvenile abundance in estuaries, however, no direct evidence has ever been presented.

As the eggs of brown shrimp are released into the surrounding sea water during spawning, there is an immediate and massive release of a jelly precursor which forms a jelly-like coat around the egg which may serve at least three important functions (Lynn and Clark 1987). It may trigger the acrosome reaction in sperm, physically protect the young zygote, contain antibacterial agents, and/or act as a repellent to other microorganisms.

Evidently nothing has been published on the larval life stages of brown shrimp. Pearson's (1939) extensive study of white shrimp larval stages is summarized elsewhere in this document.

Temple and Fisher (1967) note that off the Texas coast, planktonic stages of Penaeus species were greatest at 14.8 fathoms from August to November and in 25.2 fathoms and 44.8 fathoms from September to November. They suggest that, as these peaks corresponded to peaks in the occurrence of adult brown shrimp at these depths, the larvae were those of brown shrimp.

White and Boudreaux (1977) and Gaidry and White (1973) report that postlarval brown shrimp (16-20 mm TL) recruitment in Louisiana normally peaks from February to March. Within this pattern, recruitment in the central part of the state is normally two weeks earlier than the eastern or western portion, apparently reflecting an earlier warming of Gulf waters in the central area . Baxter and Renfro (1967) found that postlarval brown shrimp recruitment to Galveston Bay peaks in March and mid-April. Second and

third peaks are sometimes noted June through September.

Basing their claim on a comparison of their work with Baxter and Renfro (1967), Temple and Fisher (1967) proposed an overwintering of postlarval brown shrimp in the Gulf. They suggest that the postlarvae burrow in the offshore bottom and await the advent of warmer temperatures before entering the estuaries. In support of this theory, they note the laboratory work of Aldrich et al. (1967) which showed that postlarval brown shrimp burrowed at low temperatures.

In the continental shelf waters off Calcasieu Lake, brown shrimp postlarvae were found to be in statistically denser concentrations in the shallowest depths sampled, January through April. At depths less than 10 m, the average catch was 1.0 larvae/100 m^3 of water. At all other depth intervals, which ranged from 10.1 m to 90 m, the average catch was 0.4 larvae/100 m^3. These differences suggest that the larvae were concentrating near the mouth of the passes. Inshore densities of postlarvae were an order of magnitude higher than offshore catches, suggesting that the larvae had actively sought the estuarine system. Nighttime densities were significantly greater than daytime densities, suggesting that postlarval shrimp sought the bottom during the day, perhaps burrowing. Postlarval densities were also found to be correlated with water temperature, being greater at 11 to 18°C than at lower temperatures (Rogers et al. 1992).

Based on these and previous published data, Rogers et al. (1991) made the following hypothesis of a behavior-mediated and environmental triggered mechanism by which postlarval brown shrimp become concentrated near the passes of the major bays, and await the passage of a cold front in order to enter the shallow reaches of the estuary on the following frontal return. They proposed that when postlarval shrimp encounter the colder, fresher waters emanating from the estuaries that they settle out of the water column and adopt a benthic existence in the offshore area. Then once a strong cold front has moved through the system, the larvae rise into the nearshore, offshore water column and ride the warmer and saltier Gulf water as it flows into the estuary.

White Shrimp

An accurate understanding of the spawning cycle of white shrimp is only now coming into focus with the recent realization that gonadal maturation, mating, and spawning are all closely tied to the onset of darkness.

Early workers were initially unable to identify spent (spawned) female white shrimp despite the presence of many ripening and ripe females in their samples. This inability led some to conclude that a female white shrimp would spawn once and then die (e.g., Weymouth et al. 1933). Although this conclusion was criticized as premature and ill

founded by others (e.g., Burkenrood 1934), it did find its way into early management considerations. Here the argument was made that there was no need to protect the spawning stock of shrimp if the females died after their first spawn.

Later workers were able to identify spent female white shrimp. Based upon the continued low ratio of spent to ripe shrimp in their samples, these workers raised the question of whether or not a single female would spawn more than once in a season. Though they posed the question of multiple spawning, they apparently did not think that a single female would spawn more than four times in a season (Lindner and Anderson 1956).

The emerging pattern is that young of the year females do not begin to spawn until at least the April following their first winter. During the spawning season, which apparently extends from April to October, mature females may spawn every two to three days on a mating-maturation-spawning cycle which is linked to the onset of darkness. From October to December, the ovaries of the mature females may remain in the spent condition, recovering in January. The accepted rates of natural mortality are low enough that these recovered, mature females may contribute in a substantial manner to a second spawning season under natural conditions (Condrey 1991).

Our current definition of the spawning season derives largely from the field observations made by Lindner and Anderson (1956) off the Louisiana coast. They noted five stages of ovarian development: undeveloped (or resting), developing, yellow, ripe, and spent. By examining monthly plots of the percentage of captured shrimp which fell into these five categories as a function of their length, they derived the following pattern.

Female white shrimp spawned in the spring to fall of one year will not spawn until the spring to fall of subsequent years. Ovaries of the 0-year class shrimp remain undeveloped until the January of their first winter. Beginning in January, a percentage of the larger (generally greater than 150 mm TL) overwintering 0-year class shrimp begin to exhibit developing ovaries. Spawning commences in April, likely intensifies in May through August, and apparently ends in October. It occurs in Gulf water of 4 to 17 fathoms and generally involves females longer than 160 mm (Lindner and Anderson 1956; Renfro and Brusher 1964, 1965; Joyce 1965; Bryan and Cody 1975). The ovaries of the shrimp which have spawned remain in a spent condition from October until the following January, when they again begin to recover and mature (Lindner and Anderson 1956).

Throughout the spawning season Lindner and Anderson (1956) found that less than 3 to 4% of the females were in a spent condition. They noted that this continued, low incidence could be due to multiple spawning, which they did not feel would be greater than four times a season.

King (1949) studied the reproductive physiology of male and female white shrimp off the Louisiana coast and provides the following descriptions.

The ovaries of the female are bilaterally symmetrical, partly fused organs which extend from the head to the tail (the cephalothorax to the abdomen). In the head they consist of seven lobes with additional lobes extending into the tail. The immature ovaries of young females are small and transparent. As the shrimp matures, the ovaries increase in size and become opaque. As the shrimp continues to mature, the ovary takes on a yellowish cast which deepens to a yellowish orange. When the ovary is fully ripe it is a drab olive brown and fills much of the body cavity, crowding the other organs. In the spent, (spawned) shrimp, the ovary is collapsed and not as deeply colored as a ripe ovary. As the ovary again matures, the olive brown color disappears and the ovary assumes the opaque coloration of a maturing ovary, making it indistinguishable from a shrimp which has not spawned.

Histologically, King found the cells (germinal epithelium) which give rise to the eggs (oogonia) are confined to a well defined portion of the ovarian lobes which is termed the "zone of proliferation". Once formed, the eggs begin to mature, grow, and are forced by newer eggs to the peripheral regions of the ovarian lobes. The more mature eggs become surrounded by nurse cells and become filled with yolk (King 1949).

After spawning, the spent ovary contains "numerous ripe eggs undergoing reabsorption in addition to new, immature eggs". Once recovered, the formerly spent ovary is histologically indistinguishable from a newly maturing ovary. Though it is unclear how King (1949) measured recovery time (since he did not cultivate live shrimp), he felt it would require three to four months, and suggested that a female which had spawned in the spring might also spawn again in the fall. His speculation mirrored that of Lindner and Anderson (1956).

Though he did not observe spawning, King suggested that it most likely was accomplished by a coordinated contraction of the muscles of the cephalothorax and abdomen, since the ovaries contained no musculature. He noted that the lack of an efficient mechanism for facilitating the exit of mature eggs upon spawning was the likely cause for the presence of many ripe eggs remaining in the ovary after spawning.

Renfro and Brusher (1964, 1965) conducted similar analyses of female brown, white, and pink shrimp. They concurred with King's description of the ovarian development of white shrimp and found that, at this scale, King's description also applies to brown and pink shrimp.

Bray and Lawrence (1984) found that during the spawning season less than 2% of the female white shrimp in the offshore waters tested had mated during the morning hours (0900-1200 hr). In contrast, during the evening (1900-2200

hrs) the percentage of mated females had increased to over a third (36 to 42%) of the population. Bray and Lawrence also noted mating was closely associated with maturation of the ovaries and that once mated, the spermatophores began to lose their protective covering within a matter of hours. Captured shrimp were returned to the laboratory where most spawned during the night.

The weighted mean nightly spawn was estimated in their laboratory studies to be 217,000 eggs/female while the weighted mean nightly production of viable nauplii per spawn was estimated at 118,000. The annual mean hatch rate for their studies varied from 35% to 73%, with an overall mean of 54% (Bray and Lawrence 1984).

While the number of eggs which Bray and Lawrence measured in an average spawn is less than previous estimates of 500,000 to 1,000,000 eggs/female (Burkenrood 1934 and Anderson et al. 1949), the Bray and Lawrence work is consistent with King's (1949) histological studies. King found that many ripe eggs are not spawned.

Though preliminary, the work of Bray and Lawrence suggests a spawning behavior for white shrimp which is far more frequent than was suspected by earlier workers (e.g., King 1949; Lindner and Anderson 1956). Earlier workers concluded that a very low percentage of the population spawned on any single day and that months were required for a spent ovary to recover during the spawning season.

Based on Bray and Lawrence's findings, Condrey (1991) has proposed that at least a third of the adult white shrimp population will spawn on any single day at the height of the spawning season and that a spent ovary will rapidly recover allowing the individual female to spawn on a cycle of two to three days. This high level of reproductive activity is far different from the older hypothesis and is descriptive of a species which has evolved to blanket the environment with nauplii. Such a strategy would be evolutionarily beneficial, since the exchange of inshore and offshore waters is at a seasonal low during most of the spawning season.

After spawning, the eggs of white shrimp are demersal, sinking in still sea water and moving up quite freely in the water column upon agitation. The fertilized egg is nonadhesive and spherical with a diameter of 0.28 mm. Within 24 hours of fertilization the egg hatches into a free-swimming, unsegmented, first nauplius, which is nonfeeding. This stage is 0.30 to 0.34 mm in length. It possesses a single, simple eye and three pairs of swimming appendages which in the adult will serve as the first and second antennae (the "feelers") and the mandibles (innermost jaws). Yolk granules fill the body and are used as the only food source. The larvae rapidly molts through 4 successive naupliar stages (all of which do not feed), increasing in length and setae (spine-like "hairs") (Pearson 1939).

The molt from the fifth nauplius into the first protozoea occurs 24 to 36 hours after hatching and is accompanied by dramatic changes in morphology. The jaws, mouth, and larval digestive tract are fully formed and functional. Four additional pairs of appendages are present. The first two pairs are called the maxilla and assist the jaws in chewing food. The last two pairs are the maxillipeds. In the protozoea these are swimming appendages but in all later stages they will assist in chewing food (Pearson 1939).

The larvae molt through two additional protozoeal stages in which the compound eyes are now stalked, movable, and free. In these additional two molts the larvae increases in length, number of segments, and becomes more "shrimp like" in appearance (Pearson 1939).

The molt from third protozoea into the first mysis results in a dramatic development of six pairs of additional appendages. These are swimming appendages in the mysis but will become the third maxilliped (a chewing appendage) and the five walking legs (ptereopods) in the adult.

In molting into the second mysis stage the larvae grows in length from 3.2 to 4.0 mm and the first three pairs of ptereopods have fully developed pinchers (scissorlike chela) which are used in food gathering and grooming.

The molt from the second mysis into the first postlarvae is an important transition from a planktonic to a demersal life. The five thoracic walking legs have lost their swimming appendages and are now walking legs. The five pairs of abdominal swimming appendages (pleopods) now appear and are used for forward swimming (as in the adult). The second postlarval stage is approximately 4.5 to 6.0 mm in length. When provided with suitable substrate 6 mm postlarval shrimp adopted a benthic feeding behavior (Pearson 1939).

The total time required for larval development (nauplii to postlarvae) as measured in laboratory studies requires between 10 to 12 days (Johnson and Fielding 1956) and two to three weeks (Anderson et al. 1949).

The timing of peak larval abundance and of recruitment to the estuaries has received surprisingly little attention. Temple and Fisher (1967) observed that off the Texas coast the greatest abundance of planktonic stage Penaeus species occurred from May to August at 7.6 fathoms (14 m). They suggest that this peak was composed of white shrimp since the time corresponded to the reported spawning peak for white shrimp. However no direct proof of this link has ever been provided.

By the time the postlarval stage is reached, the shrimp have normally entered the estuarine nursery areas (Anderson et al. 1949) by unknown mechanisms. In some cases this recruitment may occur at an earlier stage. Anderson et al. (1949) reported that schools of adult white shrimp have been known to approach the coast and spawn close to inlets. When such spawning occurs, the eggs may

be swept through the passes on incoming currents, and larvae (nauplii) may reach the nursery grounds within a few hours. However, there continue to be no direct observations on this proposed phenomenon.

Postlarval white shrimp recruitment to the estuaries of the northern Gulf occurs over a fairly uniform time period. In Louisiana, postlarvae are primarily recruited to the estuaries from July to August though recruitment begins in June (Gaidry and White 1973, White and Boudreaux 1977). In Mississippi it extends from May through October (Christmas et al. 1966). In Texas postlarval white shrimp recruitment to the estuary extends from May through October (Baxter and Renfro 1967).

Pink Shrimp

In the northern Gulf, pink shrimp (females generally longer than 150 mm) appear to spawn from spring to late fall close to the 27 m contour (Renfro and Brusher 1982).

Pink shrimp in the Dry Tortugas area spawn year round at 12 to 26 fathoms, with a more intense spawn in spring through fall (Ingle et al. 1959; Cummings 1961; Tabb et al. 1962; Jones et al. 1964 in Perez Farfante 1969). In the Tampa and Appalachicola areas, spawning occurs in summer, and juveniles overwinter in the bays (Christmas and Etzold 1977). Matosubrato (1974) estimates fecundity at about 500,000 eggs per female. Perez Farfante (1969) suggests multiple matings for pink shrimp, since female pink shrimp shed the spermatophore upon molting.

Minimal larval development time is 15 days (Ewald 1965, Jones et al. 1964). In the Dry Tortugas, estuarine recruitment is continuous, with peaks in abundance reported for April to June (Tabb et al. 1962) and July through October (Jones et al. 1964). A May through December recruitment of pink shrimp in Mississippi is reported (Christmas et al. 1966). In Texas, Copeland and Truitt (1966) report an August to September peak in recruitment.

Seabob shrimp

Juneau (1977) reports gravid seabob females were taken in peak numbers along the Louisiana beaches in July and August, while smaller non-gravid females were taken in large numbers between December and March. He concludes that spawning most likely occurs in the Gulf between July and December.

Renfro and Cook (1963) observe that early larval development from spawning to first protozoeal stage requires 58 hours in the laboratory at 23° to 24° C and 27 ppt.

Seabob are not estuarine dependent and are found most commonly from the beach line to Gulf waters of six to seven fathoms (Renfro and Cook 1963, Juneau 1977).

Royal Red Shrimp

There are no studies of spawning of royal red shrimp in the Gulf of Mexico. However, Anderson and Lindner (1971) observed that the St. Augustine population of royal red shrimp

had a major spawning peak during the winter and spring, with some spawning occurring throughout the year. Their analysis of length-frequency distributions by sex for all sample periods combined suggests that recruitment to the fishery begins at one year of age but is not complete until the shrimp reach maturity at about three years of age. They note that the majority of shrimp taken in their samples were fully mature.

Emigration from the Estuaries

Brown Shrimp

Gaidry and White (1973) observed that under normal environmental conditions emigration of brown shrimp from the Louisiana nursery grounds occurs in two stages. The first movement normally begins at a size of 60 to 70 mm when juveniles leave the shallow marsh areas for the open bays. These bays serve as a "staging area" where the shrimp continue to grow and feed until they begin a second movement--the migration to offshore waters--at a size of 90 to 110 mm total length. This offshore movement begins in middle to late May, increases in intensity in June and July, and continues in diminished magnitude until November when essentially all the brown shrimp have left the bays.

Gaidry and White (1973) noted that some juvenile brown shrimp will emigrate at a size of 40 to 70 mm TL on strong outgoing tides. They also noted that some newly emigrated brown shrimp will reenter estuaries, usually downstream from the estuary of previous residence.

Gaidry and White (1973) noted an apparent difference in brown shrimp emigration patterns associated with estuarine configuration in Louisiana west of the Mississippi. They noted that the more open bays of Barataria, Caminada, Terrebonne, and Timbalier Bays constituted "staging areas". By contrast, the more closed bays of Vermilion and Cameron Parishes did not appear to serve as "staging areas". Gaidry and White (1973) speculated that the role might be fulfilled by the nearshore water of the open Gulf but cautioned that additional research was required. Later, White and Boudreaux (1977) reported that more extensive research resulted in the delineation of the normal staging areas as the major bays of the entire Louisiana coast. This pattern, they noted, was environmentally impacted, with shrimp emigrating at a smaller than normal size under adverse environmental conditions, such as freshettes or strong frontal passages.

Blackmon (1974) sampled a small tidal pass in Caminada Bay, Louisiana, from May to November on the full and new moons. He found that the mean length of emigrating shrimp generally increased from 79 mm in May to 98 mm in September and then declined to 84 mm in November. Mean lengths of emigrating shrimp were always greater than those remaining in the bay. During the May to

September period, the average emigrating shrimp was at least 10 mm larger than its average counterpart in the bay.

In Blackmon's study, the highest percentage of emigrating brown shrimp occurred during or just after twilight. Blackmon found no correlation between the percentage of emigrating shrimp and current speed, temperature, or salinity. Distribution of emigrating shrimp in the three-meter water column changed with time of day. During the day, peak density of emigrating shrimp was greatest on the bottom. At twilight, peak emigration occurred in the middle and at night, the peak occurred in the top meter (Blackmon 1974).

Capone (1985) conducted an onboard statistical survey of commercial wing-net vessels shrimping in the Calcasieu Ship Channel in Southwest Louisiana. He found that brown shrimp catch rates were statistically correlated with the number of hours from sunset and either moon phase or current speed. Peak catch rates were predicted to occur 3 hours after sunset on the day following a new or full moon.

Copeland (1965) sampled ebb tide March to December in Aransas Pass, Texas. He found that brown shrimp emigration peaked in association with full moons in May through August. He suggested that the high tides and faster currents of full moons stimulated emigration.

Trent (1967) sampled the main tidal pass to Galveston Bay, day and night on the ebbing tides (May to August) with a bottom trawl as well as from June to August with a surface trawl. Catch per unit effort was greater on the bottom during the day and at the top during the night, though the difference was not significant.

Trent (1967) found two peaks in abundance of emigrating shrimp: one in mid-May and another in mid-June. The mean size of emigrating shrimp increased linearly from 58 mm on May 18 to 108 mm on July 28 or 3.6 mm per week.

White Shrimp

White shrimp that enter the Louisiana estuaries as postlarvae in the spring and early summer emigrate to the Gulf September through November (Gaidry and White 1973). Those white shrimp postlarvae recruited to the estuary later in the summer and early fall are apparently forced offshore by advancing cold fronts in October to December at a size much smaller than that of shrimp emigrating in the summer. These "later-recruited" white shrimp overwinter in the nearshore Gulf and reenter the estuaries at an average size of 100 mm during the spring warming. After a second period of growth, they emigrate to the Gulf to spawn in the spring and early summer (Lindner and Anderson 1956; Gaidry and White 1973).

Gaidry and White (1973) noted that the staging areas for white shrimp were also the larger open bays. With white shrimp staging areas Gaidry and White (1973) noted three important time periods in relationship to white shrimp

size. The first occurs from July to September and is characterized as a time of increasing average size of shrimp, going from about 90 mm TL in July to 110 to 130 mm TL in September. In the second period average size declines from October to December, going from about 90 to 110 mm TL in October to about 60 to 80 mm TL in December. The third is a period of again, increasing average size, going from 70 to 80 mm TL in January to 120 to 140 mm TL in May. They note the first period coincides with rapid growth of newly recruited juveniles spawned in the spring and summer. The second period coincides with (a) emigration of these newly recruited, rapidly growing shrimp (b) diminished growth of late recruited juvenile shrimp as water temperatures fall, and (c) early emigration of late recruited juvenile shrimp associated with advancing cold fronts. The third period coincides with emigration of over-wintered white shrimp.

Based on the similarities in the behavior of brown and white shrimp, Gaidry and White 1973 recommended the following two types of management divisions of Louisiana's waters. First they recommended an east-west division of the State coastal zone into the following three geographical districts: (a) from the Mississippi border to the Mississippi River, (b) from the Mississippi River to the Atchafalaya River, and (c) from the Atchafalaya River to the Texas Border.

Second they also recommended a north-south division of the State's coastal zone into primary nursery areas (shallow estuarine waters), staging areas (deeper, open bays), near offshore waters and offshore waters.

Gaidry and White (1973, p. 150) recommended permanently closing the nursery grounds for brown and white shrimp since in almost every case, studies have shown that the smaller, shallow nursery areas do not produce a commercial size shrimp (100 count brown). They recommend that the nursery areas should be closed to all trawling activities on a permanent basis. The employment of this measure would eliminate the wasteful destruction of the unusable small shrimp, and at the same time perpetuate a sustained yield of larger, more desirable shrimp in the larger embayments (staging areas) along the coast.
They argue that such measures would increase yield and value, while eliminating the need for minimum sizes and extending the open season in many estuaries. Later, White and Boudreaux (1977) further clarified the definition of the nursery and staging grounds and stressed the benefits to the industry of closing the nursery grounds.

Pink Shrimp

Apparently nothing is reported on emigration patterns of pink shrimp in Louisiana. Emigration patterns of pink shrimp in Texas are not clearly understood (Cody et al. 1989), though some pink shrimp overwinter in Texas bays and reside in the estuaries up to 9 months (Jackson 1975).

In the Everglades nursery areas, Yokel et al. (1969)

observed that juvenile pink shrimp emigrate almost exclusively at night, and on night ebb rather than night flood tides. On the average, catch per unit effort of emigrating pink shrimp was nearly twice as high during new and full moons (37 shrimp per minute) as during the first and third quarters (20 shrimp per minute). However, this effect of moon phase was dependent upon the relative abundance of pink shrimp: negligible when shrimp abundance was low, and substantial when abundance was high.

They observed that the size of emigrating shrimp ranges from 2 to 45 mm (carapace length), and averaged 14 mm (carapace length). Using Kutkuhn's (1966) carapace length vs. weight plot for pink shrimp, this size range equates to a weight range of up to 80 g for male shrimp and an average of 2.0 to 2.5 g for male and female shrimp. Thus the average shrimp leaving the Everglades is in the 300 to 200 tails per pound range.

In a similar study in the Everglades, Beardsley (1970) observed that emigrating pink shrimp on the ebb tide were attracted towards moonlight, though the majority of the emigrating shrimp were always found in the surface waters.

Migration Patterns in Offshore Waters

Brown Shrimp

Brown shrimp released off the Mississippi coast in June (Klima and Benigno 1965) traveled less than an average of one mile per day from the release site. An offshore movement was not apparent since less than one percent of returns came from waters deeper than 16 fathoms. The longest distance traveled was 85 miles--from the release site off Horn Island to the Mississippi River's Southwest Pass. This information indicates that the present, artificial configuration of the Mississippi River may not be an absolute barrier to adult brown shrimp migration.

Most of the brown shrimp released off Grand Isle, La., in July (Klima 1964) were recaptured near the release site. A slight seaward and westward movement was noted.

Movement of brown shrimp released off Galveston, Texas in July led Klima (1964) to suggest that brown shrimp from the Galveston estuary were recruited to the fishery all along the Texas Coast.

Brown shrimp released off the Central Texas coast at 21 to 24 fathoms in April (Klima 1964) showed little coastwide movement. No major offshore movement was apparent from April to June because 99 percent of the returns were within 25 fathoms and none were beyond 30 fathoms.

Sheridan et al. (1987) noted a net southward movement of tagged brown shrimp released near the U.S.-Mexican border.

From an examination of commercial catch trends, Gunter (1962) suggested a southward drift of brown shrimp off the Texas coast in the fall.

Condrey (1979) suggests that the commercial catch

statistics indicate brown shrimp exhibit a general migration out to the deeper waters of the Gulf. He noted that the inshore catch peaked in May to July on shrimp smaller than those measuring 67 tails to the pound. Then, after Texas opened its Territorial Sea, offshore brown shrimp catch in the Gulf as a whole peaked in July and August at depths of 11 to 20 fathoms, with a mode in the landed shrimp at 31 to 40 tails to the pound. By December, the largest catch came from 26 to 30 fathoms, where 15 to 20 tails to the pound shrimp predominated. He suggested that the data indicated a four to five fathom per month depth migration from July to December.

White Shrimp

Other than the offshore-onshore migrations and a tendency to concentrate between Ship and Trinity Shoals, Lindner and Anderson (1956) observed no definite migration patterns of white shrimp along the Louisiana coast west of the Mississippi River during the fall and winter.

Klima (1964) noted a coastwide movement or dispersion of tagged white shrimp along the Louisiana coast between Cameron and Vermilion Bay. Perret et al. (1978) observed that movement along the western portion of the Louisiana coast was mainly westerly, though the majority of the tagged shrimp were returned within 60 nautical miles of the release area.

White shrimp east of the Mississippi River to Mobile Bay tend to migrate from the estuaries to deeper waters along the barrier islands and towards the Mississippi River Delta during the summer to fall (Lindner and Anderson 1956). Because they did not observe marked shrimp crossing the Mississippi, Lindner and Anderson (1956) suggested that the Mississippi River may act as a barrier to east-west movement. This view was supported by Perez Farfante (1969).

Lindner and Anderson (1956) observed a migration of white shrimp from off the coast of Mexico to Aransas Pass, Texas, during the spring. They hypothesized a reciprocal southward movement from central and southern Texas into northern Mexico during the fall and winter. From an analysis of reported commercial catch patterns, Gunter (1962) suggested a similar southward movement of white shrimp.

Pink Shrimp

Juvenile pink shrimp emigrate from the estuaries of southern Florida into the deeper waters of the Gulf. Costello and Allen (1965) found that the nursery grounds of pink shrimp on the Tortugas grounds were estuaries from Florida Bay and from as far north as Indian Key, whereas the nursery grounds of shrimp on the Sanibel grounds were estuaries from Indian Key north to Pine Island Sound. They observed little movement of shrimp between the Tortugas and Sanibel grounds.

Iverson et al. (1960) observed that larger pink shrimp tended to occur at

deeper depths on the Tortugas grounds. He derived the following equations relating size and depth:

Males:

$$L_c = 16.394 + 0.618 \times D$$

Females:

$$L_c = 17.914 + 0.868 \times D$$

Sexes combined

$$L_c = 17.307 + 0.739 \times D$$

where L_c is carapace length and D is depth in fathoms.

Off southern Texas, pink shrimp tagged near the U.S.-Mexican border demonstrated variable movements and with no net north-south migration (Sheridan et al. 1987).

Seabob Shrimp and Royal Red Shrimp

Immediately following passage of a cold front, seabob shrimp along the Louisiana coast migrate toward the beach from offshore areas. In July and August, gravid females also move close to shore (C.J. Juneau, personal communication in Christmas and Etzold 1977).

Apparently nothing is recorded about migration patterns of royal red shrimp.

Substrate Preferences

General

Though it is generally believed that the substrate preferences of shrimp appear to be important to their distribution patterns along the Gulf coast, these observations on distributions are not supported by the limited experimental data on substrate selection as discussed below. Despite this uncertainty over substrate selection, brown, white, and seabob shrimp seem to prefer soft mud or peat bottoms and are found mainly along the coast from Texas to Alabama. Pink shrimp seem to prefer calcareous sediments and are found mainly along the Florida coast.

Brown and White shrimp

Because of their distribution, juvenile brown and white shrimp seem to prefer a soft mud or peat bottom with large quantities of decaying organic matter or vegetation (Williams 1955, 1958; Mock 1967; Jones 1973). Sand or clay substrates sometimes appear to be satisfactory for young brown shrimp, unless these substrates are bare clay, sand, or shell (Williams 1959). Adult brown shrimp are found on mud or silt and also on mud, sand, and shell (Perez Farfante 1969). In the Gulf, white shrimp are also found on muddy or silty bottoms and on clay or sand with fragments of shell (Springer and Bullis 1954; Hildebrand 1954, 1955).

In contrast to these distributional patterns, when presented with a choice between sandy-mud (20-40% sand), sand, and shell substrates, brown and white shrimp exhibited a weak preference for sandy-mud in a pattern which may be affected by size, salinity, and temperature. With brown shrimp the percentage of shrimp selecting for sandy-mud

increased from 45 to 65% as shrimp increased in size from 73-104 mm to 115-156 mm. This same percentage decreased with decreasing salinity, going from 59 to 43% as salinities decreased from 21-30 ppt down to 11 to 17 ppt (Rulifson 1981). With white shrimp, increasing temperatures decreased the weak affinity for sandy-mud. Here the percentage of shrimp selecting sandy-mud went from 50% to 26% as temperatures increased from 23-24° C to 25-28° C. At salinities of 20-25 ppt, only 27% of the white shrimp selected for sandy-mud, while at salinities of 26-29 ppt 51% selected for sandy mud (Rulifson 1981).

Pink Shrimp

Pink shrimp are believed to prefer firm mud or silt bottoms with coral sand containing a mixture of mollusk shells (Springer and Bullis 1954, Hildebrand 1954, 1955, Williams 1958) and firm sand bottoms (Perez Farfante 1969). However, when presented with a choice between sandy-mud (20-40% sand), sand, and shell substrates, pink shrimp (64 to 112 mm) exhibited no preferences at temperatures which ranged from 18 to 29° C and salinities which ranged from 10 to 30 ppt (Rulifson 1981).

Seabobs and Royal Red Shrimp

Seabob shrimp are taken from bottoms of mud, silt, or silt mixed with sand (Nerva 1967, Christmas and Etzold 1977).

Royal red shrimp show no apparent preference for a particular sediment type; they occur on sand, silty sand, terrigenous, and calcareous sediments (Roe 1969).

Estuarine Habitat Preferences of the Major Species

Brown and White Shrimp

During the estuarine phase of their life cycle, small brown shrimp appear to have a greater preference for vegetated areas than do small white shrimp. Loess (1965) found 15-70 mm brown shrimp were more abundant in beds of Rupia and Vallisneria in Mobile Bay, but that white shrimp of this size range were more abundant in open areas that had large concentrations of detritus. Similarly, Stokes (1974) found white shrimp were most often found in open areas of the Laguna Madre, while brown shrimp were distributed across open areas and in beds of sea grass.

When the surface of the Spartina alterniflora marsh was flooded, Zimmerman and Minello (1984) and Zimmerman et al. (1984) found greater concentrations of postlarval and juvenile brown shrimp there than in adjacent nonvegetated areas. However, they found no differences in the distribution of juvenile white shrimp between flooded marsh and adjacent water bottoms. Noting that the major wave or waves of juvenile brown shrimp enter the marshes during the period of highest tides and water levels (spring and fall), Zimmerman

and Minello suggest that the ability of brown shrimp to use the marsh surface may have evolved because of some selective advantage. Selective pressure on juvenile white shrimp to use the flooded marsh surface would not have a strong evolutionary component, they argue, since white shrimp are present in the marshes when water levels are seasonally low and the marsh is less frequently flooded.

Zimmerman et al. (1984) found that densities of juvenile brown shrimp in flooded marshes were directly correlated with densities of Spartina, being highest where the grass density was greatest. They also observed higher concentrations of smaller shrimp in the marsh grass as opposed to the adjacent open water. Between 89 to 96 percent of the juvenile brown shrimp less than 50 mm were found in the marsh. This percentage remained high but declined to 75 to 78% of the population for brown shrimp which were between 50 and 90 mm.

There are conflicting reports as to whether or not brown shrimp displace white shrimp from vegetated areas. In laboratory studies, Giles and Zamora (1973) found that juvenile brown and white shrimp selected for vegetative cover when held separately, but that brown shrimp displaced white shrimp from the vegetated areas when the two species were held together. In similar studies, but using artificial vegetative cover, Minello and Zimmerman (1985) found that brown shrimp strongly selected for cover during the day (70 to 80% of the specimens), but not at night; while white shrimp showed no cover selection, day or night. Further there was no displacement of white shrimp from the artificial cover when brown shrimp were introduced.

The presence of nonfeeding Atlantic croaker (Micropogon undulatus) (nonfeeding because their mouths were sewn closed) did not affect the laboratory distribution patterns of brown or white shrimp (Minello and Zimmerman 1985). When the Atlantic croaker were allowed to feed on the shrimp, Minello and Zimmerman did note that the mean percentages of brown shrimp in the vegetated areas did increase, but these increases were not significant. There was no affect of presence of this feeding predator on white shrimp distributions. The activity of the croaker which were allowed to feed tended to negate any avoidance behavior of the shrimp, since the fish, which were most active at night, swam freely through the artificial cover in search of shrimp.

Pink Shrimp

In southeastern Florida, Sheridan (1991) found that seagrass beds were by far the most important estuarine habitat for juvenile pink shrimp, accounting for 74% of the shrimp captured in this study. Grass beds were followed in importance by open water bottoms (22%) and to a far lesser degree by mangroves (4%) as habitats. The findings suggest that recent major seagrass die backs in southeastern Florida may be directly related to recent

declines in pink shrimp production in the area. However, Sheridan (1991) suggests that these impacts may be mitigated by recolonization of die-back areas by algae and then by seagrass species.

Effects of Temperature and Salinity

Though postlarval brown and white shrimp are able to tolerate a broad salinity range, there is an apparent interaction of salinity and temperature on growth and mortality. Zein-Elden and Griffith (1969) observed that growth and survival of brown shrimp postlarvae in the laboratory exhibited a marked increase at salinities of 5 to 35 ppt. as temperature was increased from 18 to 25° C. Maximum production appeared to occur in the range of 25° to 32.5° C and 5 to 35 ppt. Growth and survival of white shrimp postlarvae was highest at 25° to 32.5° C and at intermediate salinities of 5 to 15 ppt (Zein-Elden and Griffith 1969).

The major influx of postlarval brown shrimp to the estuaries of the northern Gulf occurs February to March (Baxter 1973, Baxter and Renfro 1967, Gaidry and White 1973, Christmas and Etzold 1977). Little growth is expected until water temperature exceeds 20° C (St. Amant et al. 1962,Ford and St. Amant 1971).

In Louisiana, a correlation has been drawn between the annual success of the brown shrimp harvest and the temperature of both the estuarine water during mid-April and the acres of marsh above 10 ppt (Barrett and Gillespie 1973, 1975, Barrett and Ralph 1976). In general, good production is expected if the spring is dry and warm, whereas poor production is expected for a wet, cold spring.

A multiple regression equation was generated in the development of the federal shrimp plan correlating U.S. brown shrimp catch to Louisiana estuarine conditions. The equation,

$$\text{Catch} = -51.73 + 3.664 \times (\text{Temp}) - 0.01496 \times (\text{River}) + 0.5061 \times (\text{Effort})$$

predicts a direct relationship between temperature in April and the resulting annual catch of brown shrimp.

The first cohorts of postlarval white shrimp normally enter the major bays of the Gulf when temperatures are above 25° C (Baxter and Renfro 1967) and are apparently optimum for growth and survival. As the temperatures decline in the fall with advancing cold fronts, growth apparently also declines (Lindner and Anderson 1956; Klima 1974; Nichols 1981).

Annual production of white shrimp in Louisiana and the northern Gulf has been associated with estuarine salinity regimes. A similar salinity effect, caused by different weather patterns seems to operate in Louisiana and Texas. Gunter and Edwards (1969) observed a positive correlation (R^2= .43) between the annual successes (1922-1964) of white shrimp in Texas

with the rainfall in the state for that year and the two previous years. They suggest that the lag effect of rainfall was a result of the arid conditions of the state. In Louisiana, an inverse relationship between annual white shrimp catch and the annual discharge of the Mississippi and Atchafalaya Rivers has been noted (Barrett and Gillespie 1973). White and Boudreaux (1977) obtained statistically significant linear regressions of catch against river discharge by dividing the data into two periods, 1958-1968 and 1969-1974.

Gunter and Edwards (1969) suggest that high rainfall is necessary in Texas to dilute the estuaries for optimum white shrimp production, while lower than normal river discharge is necessary in Louisiana for optimum white shrimp production, since these estuaries were less saline than those of Texas.

In the development of the federal shrimp plan, Louisiana's reported commercial catch of white shrimp (on a year-class basis) was correlated with unit fishing effort (Griffin 1978) and Mississippi River discharge by the following equation:

$Y = 129.1 + .6411 * E - 51.48 * LMD$
$(R^2 = .89)$

where Y is yield in million pounds of tails, LMD is the log of the average river discharge in 1000 cfs for the May through December period, and E is 1000 units of unit effort.

The equation denotes an inverse relationship between white shrimp yield in Louisiana and river discharge over this time period.

Growth of postlarval and juvenile pink shrimp in Florida appears to decline as salinity increases from 10 to 28 ppt and may increase as temperature increases from 15° to 32° C (Higman et al. n.d.). This apparent relationship between growth and salinity is in contrast to the observation that juvenile pink shrimp normally occupy a higher salinity area on nursery grounds than do brown or white shrimp (Gunter et al. 1964).

Highest densities of royal red shrimp are found at 9° to 10° C and most occur within 8° to 12° C (Roe 1969).

Food Preferences

Larval Stages

Though planktonic (i.e., swimming freely in the water column, but not able to swim against a strong current), the naupliar stages do not feed but rely on yolk material for growth and development (Pearson 1939, Christmas and Etzold 1977). The protozoea and mysis stages are planktonic and ingest algae and zooplankton (Pearson 1939, Ewald 1965). Offshore development of these larvae in the less rich waters of the Gulf may be necessary because of the many setae (hair-like spines) on their swimming appendages and voracious appetites. Early workers observed that these stages could only be fed "small

amounts of algae" (Pearson 1939) or the animals would become entangled and die in the filtered algae and their own feces (which are string-like in nature).

Wilkenfeld et al. (1984) raised brown and white shrimp larvae on a variety of mixed animal and algal diets. The highest percent metamorphosis and greatest mean dry weights were obtained on diets consisting of diatoms and artemia or of diatoms and nematodes. Significantly lower metamorphosis success and/or growth was obtained on diets consisting of only diatoms, only dinoflagellates, dinoflagellates and artemia, and dinoflagellates and nematodes.

Larval growth in the wild may be greatly influenced by the availability of prey once the nauplii begin feeding, especially depending on the nutritional adequacy of the eggs upon spawning. Kuban et al. (1985) obtained 98% to 100% metamorphosis to the postlarval stage of larvae fed on diets of diatoms, diatoms and Artemia, and phytoflagellates and Artemia. However, they noted in most, but not all, cases that the resulting postlarvae were heavier when the Artemia were introduced at the second protozoea substage (the second feeding stage) rather than the first mysis substage (the third feeding stage). They note the mixed results could be a result of the nutritional physiology of the eggs upon spawning.

Postlarvae

It is at the postlarval stage that the shrimp makes the transition from planktonic to bottom (deposit) feeding (Pearson 1939). In early laboratory experiments Pearson introduced postlarvae into an aquarium with an estuarine bottom deposit of fine sand and organic debris. After a period of acclimation, the shrimp assumed a bottom (benthic) feeding behavior and at a size of 15 mm began to also eat other introduced foods such as raw fish, angleworms, and shrimp meal (Pearson 1939). Zien-Elden and Griffith (1969) have fed postlarval shrimp on algae, Artemia salina nauplii, and ground fish or shrimp in the laboratory.

Postlarval brown shrimp exhibit a rapid turnover of carbon and growth (Fry and Arnold 1982) on diets of ground shrimp and squid and Artemia nauplii.

Gleason and Zimmerman (1984) studied the growth and survival of wild caught brown shrimp postlarvae for 16 days on all possible combinations of four sources of plant material: Spartina detritus, epiphytes of Spartina, the diatom Skeletonema, and Isochrysis sp. Growth rates were statistically correlated with a principal food group, being highest on Skeletonema combinations, intermediate on epiphyte combinations without Skeletonema, and nonexistent with the Spartina detritus, Isochrysis, and no food treatments. There was no significant difference in survival between the Skeletonema and epiphyte treatments, and these treatments' survivorships were significantly higher than the Spartina detritus, Isochrysis,

and no food treatments. Plant material can be an important component of the natural diet of postlarval shrimp, but the animal component of the shrimp diet is probably important because the growth rates which they observed on plant diets alone were much less than reported from the wild. Gleason and Zimmerman (1984) also questioned the importance of detritus in the diet of shrimp since no growth was observed unless Skeletonema or Spartina epiphytes were a part of the diet.

Gleason (1986) found that the carbon turnover of shrimp fed Skeletonema alone or in a mixture of all food sources was not significantly different from that found for postlarvae raised on animals diets. This result supports the hypothesis that some naturally abundant and available plant sources may be important in the growth of postlarval brown shrimp. Gleason (1986) also found that assimilation of the other plant sources was not significant.

Small postlarval brown shrimp (11 mm) consumed and assimilated plankton and demersal fauna in the estuarine environment but did not grow on Spartina alterniflora detritus or epiphytes (Gleason and Wellington 1988). In caged experiments where postlarval brown shrimp were given different substrates, Gleason and Wellington found that the only significant difference in growth was due to the presence or absence of plankton in the water column. Those animals which had a natural supply of plankton averaged twice the final weight of animals caged within netting which restricted plankton entrance. Within plankton treatment there was no significant effect of substrates type: Spartina detritus, epiphytes, detritus/epiphytes, and no substrate.

By measuring the impact of the feeding shrimp on the faunal assemblages in these enclosures and the change in stable carbon isotope ratios in the shrimp and food sources, Gleason and Wellington estimated that the demersal fauna and plankton accounted for 53% and 47% of the growth of these small postlarval shrimp. They suggested that the use of Spartina alterniflora epiphytes and detritus by shrimp larger than 25 mm reflected an ontogenetic change in food-resource use or assimilation efficiencies.

In a followup study, McTigue and Zimmerman (1990) fed postlarval brown and white shrimp diets very similar to those used by Gleason and Zimmerman (1984) but with the addition of the Artemia nauplii as an animal component to the diet. They observed highest growth rates with a combination diet of Artemia and Skeletonema. These growth rates greatly exceeded those observed by Gleason and Zimmerman (1984).

Juveniles and Adults

Juvenile and adult brown, white, and pink shrimp are considered omnivores, ingesting whatever is available, including decaying organic matter, animals, and plants (Viosca 1920, Weymouth et al. 1955, Flint 1956, Darnell 1958, Brood 1965, Perez Farfante

1969, Jones 1973).

Jones (1973) intensively studied the food habitats and absorption (transport across the gut wall) efficiency of brown shrimp 25 to 104 mm in a Louisiana marsh. He observed a shift in diet and habitat as shrimp grew larger. Juveniles 25 to 44 mm were concentrated in the near-shore environment where they indiscriminately ingested the top layer of sediment containing decaying marsh plant tissue, fecal pellets, and microorganisms. Jones classified this stage as omnivorous or encounter-feeders. At 45 to 64 mm shrimp selected the organic fraction of the sediment; this stage was classified as opportunistic omnivores. At 65 to 104 mm shrimp dispersed from the near-shore environment to the deeper waters of the marsh and became active predators feeding on polychaetes, amphipods, nematodes, and chironomid larvae. However, they continued to ingest detritus and algae and were classified as omnivore predators (Jones 1973).

Darnell (1958) found the foreguts of white shrimp 91 to 142 mm contained sand, detritus and ground organic matter, and fragments of mollusks, ostracods, copepods, insect larvae, and forams.

Eldred et al. (1961) found pink shrimp in Tampa Bay contained both animal and plant remains. These included aquatic macrophytes, red and blue-green algae, diatoms, dinoflagellates, polychaetes, nematodes, shrimp, mysids, copepods, isopods, amphipods, mollusks, forams, and fish.

Nothing is apparently recorded on the food habits of seabob or royal red shrimp.

Predation

Penaeid shrimp are ingested by many carnivorous fish (Gunter 1945, Darnell 1958, Perez Farfante 1969). Table XXIX lists some fish known to ingest brown, white, or pink shrimp. Included in this list are speckled trout, black drum, red drum, Atlantic croaker, southern flounder, bass, and several varieties of catfish. It is noteworthy that many of these predatory species are an important component of the by-catch discarded by shrimpers.

Minello and Zimmerman (1983) studied the effect of a simulated Spartina marsh on the predation rates of four finfish which were allowed to feed on juvenile brown shrimp. To create their simulated marsh they used plastic straws arranged in three stem densities. They found that the artificial vegetation cover did not affect the predation rates of red drum and spotted seatrout, but did reduce those of pinfish and Atlantic croaker. The overall daily consumption rates, in percent body weight per day, were 10 to 31% for red drum (154-245 mm), 18 to 31% for spotted seatrout (119-170 mm), 11 to 27% for Atlantic croaker (115-133 mm), and 17-44% for pinfish (61-74 mm).

Red drum and spotted seatrout were classified as extremely efficient predators in the Minello and Zimmerman

study. Both spent little time pursuing shrimp, and both rarely lost a shrimp once they began pursuit. Pinfish and Atlantic croaker were classified as inefficient predators, requiring several attacks before a successful kill. Pinfish frequently attacked in groups, with the largest fish generally preventing the others from feeding on the killed shrimp until it abandoned the remains. Red drum and Atlantic croaker fed continuously on the shrimp, while pinfish fed only during the day. The day-night feeding cycle of spotted seatrout was not investigated.

Minello et al. (1987) examined the effects of turbidity and substrate (sand) on the ability of a number of fish to prey on brown shrimp 62 to 126 mm. With southern flounder which were 84 to 94 mm, predation was increased by the lack of substrate and by the presence of turbid water. Lowest predation rates occurred in the presence of clear water and sand, and highest rates occurred without sand and in turbid water, being 1.5 and 6.5 shrimp/fish/12 hr. Minello et al. noted that the southern flounder used a variety of feeding behaviors, but generally remained motionless on the bottom and waited for prey to come within striking distance. This ambush feeding tactic was enhanced in turbid waters, because the brown shrimp are more active under such conditions, and therefore more likely to encounter the waiting flounder.

Highest predation rates by pinfish occurred in clear water with no sand. Here the predation rates averaged 8 shrimp/fish/12 hr, and was probably underestimated since in 3 of the 4 studies all the shrimp were eaten by the end of the 12 hr experiments. Similar predation rates were noted in turbid water experiments, whether or not sand was present, and ranged from less than 2 to greater than 3 shrimp/fish/12 hr (Minello et al. 1987). The sight dependent feeding strategy of these fish was enhanced by the clear water treatment.

With Atlantic croaker, Minello et al.'s results were less clear, apparently because Atlantic croaker feed more actively at low light levels, and incident light was allowed to vary within and between the experiments. Predation rates were higher in clear water, but not significantly. Minello et al. suggest that turbidity should not act as a greater hinderance to shrimp predation by Atlantic croaker as it is to pinfish since croaker use olfaction and touch in locating prey and pinfish rely on sight.

Predation by red drum on brown shrimp did not appear to be affected by turbidity or sand substrate (Minello et al. 1987), probably because red drum's method of feeding allows them to locate animals in shallow burrows (Yokel 1966).

Chapter 5 - Stock Assessment

Growth Rates

General Considerations

As in most fisheries, growth rates are estimated from changes in the length of the species with time. Growth in weight is estimated by converting growth in length estimates to weight.

The method of measuring growth varies with the size of shrimp. Growth (in length) of "smaller" shrimp (25 to 90 mm total length) is normally estimated from length frequency measurements of trawl samples taken in estuarine nursery areas over a period of time. Growth is expressed as the increase either in the mean size of the trawl sample or in each of the peaks in the polymodal length-frequency data with increasing time. A linear relationship of length increase with time is assumed. Growth estimates range from 0.1 to 3.3 mm per day. Variability has been attributed to temperature, salinity, recruitment, density, and emigration.

Growth of "large" shrimp (greater than 70 mm total length) has normally been estimated from mark and recapture experiments. A simple linear relationship of length (or weight) to time is not considered applicable. Rather, it has been normally assumed that the von Bertalanffy growth equation (von Bertalanffy, 1938), or its mathematical counterpart, the Walford equation (Walford, 1946), applies. Use of these equations assumes that the shrimp have entered a self-limiting period of growth. Parrack (1978) tested various growth models for brown shrimp to determine which provided the best fit. Nichols (1981), noting the effect of temperature and size on growth of white shrimp, used an empirical model to fit his data.

Brown Shrimp

Published growth rate estimates of estuarine populations vary from 0.1 to 3.3 mm per day. Variation is in large part associated with the month of measurement. Growth in length is slow (0.5 mm per day) during January and

February, increases in March, and reaches a maximum (0.5-3.3 mm per day) in April and June (Loess 1965, Ringo 1965, St. Amant et al. 1966, Broom 1968, Ford and St. Amant 1971, Jacob 1971).

This monthly variation in growth rate has been associated with the spring warming of the estuaries (St. Amant et al. 1962, Ford and St. Amant 1971). For example, little growth of juvenile brown shrimp in Barataria Bay, Louisiana, occurs until after the first three weeks in April when water temperatures normally warms above 20° C (Ford and St. Amant 1971). Zein-Elden and Griffith (1969) noted that growth of postlarval brown shrimp increased rapidly as water temperature was raised above 17.5° C and reached a maximum at about 25° C.

St. Amant et al. (1965) studied growth of juvenile brown shrimp in Barataria Bay, March - May. They observed population growth rates which ranged from no growth to 2.5 mm TL/d. They noted that growth tended to be less than 1.0 /mm TL/d when temperatures were less than 20° C and less than 1.5 mm TL/ d when temperatures were less than 25° C.

Gaidry & White (1973) vividly demonstrated the relationship between juvenile brown shrimp size/growth and commercial production , contrasting low (1965) and high (1971) production years. They note that 1965 juvenile brown shrimp averaged less than 20 mm TL on March 10th in Barataria Bay and by April 20th the average size barely exceeded 40 mm TL. This slow growth (and low abundance) resulted in poor production. In contrast, in 1971 brown shrimp in the area averaged greater than 35 mm TL on March 10th and exceeded 60 mm TL by April 20th. This rapid growth (and high abundance) resulted in good production.

Parrack (1978) studied the growth rate of brown shrimp (71 to 213 mm total length) from mark and recapture data collected in the northern Gulf of Mexico in 1967, 1968, and 1969 (Clark, Emiliani, and Neal 1974). He examined the fit of several different growth models and concluded that the von Bertalanffy equation provided the best fit for growth in length, while its mathematical counterpart, the monomolecular, provided the best fit for growth in weight. His sex specific growth rate equations are:

Von Bertalanffy

Males:

$$L = 168.7\ (1 - 0.9979e^{-0.3357*a})$$

Females:

$$L = 193.6\ (1 - 0.9962e^{-0.3363*a})$$

Monomolecular

Males:

$$W = 43.51\ (1 - 0.9999e^{-0.154a})$$

Females:

$$W = 74.32\ (1 - 0.9999e^{-0.141a})$$

where L is the total length in mm, W is total weight in grams, and a is age in months.

His discussion indicated that females grow more rapidly than males, weigh more than males of the same age, and attain a larger final length and weight than males. Comparing his findings with those of Chavez (1973) and McCoy (1972), he noted that brown shrimp off

Mexico exhibited a faster and more prolonged growth, whereas brown shrimp off North Carolina had a faster growth but reached a smaller final size than northern Gulf populations. He speculated that the differences were due in part to temperature and technique.

Parrack (1981) tested for common growth rates among tagged brown shrimp released at various locations along the Louisiana, Texas, and Mexican coast during 1978-1980. He found that growth did not differ for the Texas-Mexico releases but did differ significantly between treatments for the Louisiana releases.

For this reason Parrack (1981) fitted von Bertalanffy kinetics to the pooled Texas and Mexico data and attempted to fit von Bertalanffy kinetics to the individual Louisiana treatments. He failed to obtain significant fits to data collected on brown shrimp tagged and released inshore in Louisiana, but did obtain significant fits for the Texas-Mexico releases and for the one offshore Louisiana release. He suggested the use of the Texas-Mexico data generated equations is justified to describe growth along the Louisiana coast since (1) the solutions obtained for the one offshore Louisiana release are similar to those for the Texas-Mexico release and (2) the Texas-Mexico equations fit the Louisiana data reasonably well.

For the purposes of this plan we will use Parrack's (1981) sex specific growth rate equations derived from his Texas-Mexico releases. However, a reanalysis of the Louisiana data is more than justified. Parrack's equations have the form:

Males:

$$L = 97.5601\ (1 - e^{-(.2592*a)})$$

Females:

$$L = 113.9349\ (1 - e^{-.2882*a})$$

where L is tail length in mm and a is age in months.

White Shrimp

Growth rates of white shrimp estimated from trawl samples range from 0.6 to 2.2 mm per day in the summer (Williams 1955, Gunter 1956, Loesch 1965).

Growth rates of white shrimp have been estimated by a number of workers from mark and recapture experiments.

Lindner and Anderson (1956) marked white shrimp 85 to 180 mm total length in the South Atlantic and northern Gulf. The results indicated that growth in length was a function of size and month, growth being faster for the smaller than the larger shrimp, and faster in April to June and September to December than from December to March. Their sex specific growth rate equations are:

Summer to Fall, East of the Mississippi River
Males:

$$L_t = 17.2\ (1-0.764^t)$$

Females:

$$L_t = 17.4\ (1-0.768^t)$$

Spring, West of the Mississippi River
Males:

$$L_t = 17.2\ (1-0.526^t)$$

Females:

$$L_t = 18.4\ (1-0.570^t)$$

Summer to Fall, Texas
Males:

$$L_t = 14.9\ (1-0.799^t)$$

Females:

$$L_t = 15.8\ (1\text{-}0.781^t)$$

where L is length (in mm) at time t (in 30 days).

Klima (1964) measured the growth of tagged white shrimp (13.3 to 41.1 g) along the west Louisiana coast during September to November, 1962. He derived a von Bertalanffy equation to described growth,

$$W_t = 87\ g\ (1\text{-}e^{-0.12\ (t\text{-}1\text{-}0.571)})^3$$

where W is weight in grams at time t in weeks. From a later experiment with white shrimp (100 to 160 mm) in Galveston Bay (August to October), Klima (1974) estimated growth rate as

$$L_t = 214\ mm\ (1\text{-}e^{-0.009\ (t\text{-}0.2)})$$

where L is length in mm at time t in weeks.

In comparing the results of the two experiments, he noted that growth was faster in August to October than in September to November. He suggested that the difference was due to differences in water temperature.

The most comprehensive growth rate equations for white shrimp were developed by Nichols (1987) from mark-recapture experiments conducted by NMFS/LDWF off the Louisiana coast from July 1977 to December 1980. Shrimp were marked by inserting numbered, plastic, flat, yellow ribbons through the musculature of the first abdominal somite and released near their inshore or offshore marking sites (Phares 1980). Recaptures were made by shrimpers who found the marked shrimp in their trawls.

Nichols was hampered in his analysis by the existence of a number of improbable growth rates which he attributed to "measurement errors". These "measurement errors" resulted in a range of daily growth rate values from -9 to +7 mm/d (tail length). To minimize the affects of these "measurement errors" on his calculations, Nichols made a subjective decision to confine his analysis to growth rates which varied from -0.5 to +1.5 mm/d (tail length). This decision resulted in the elimination of 10% of the data set.

To investigate the sex-specific relationship between growth, size, and temperature, Nichols first grouped the data into cells of 5 mm tail lengths (in a range of from 45 to 110 mm tail length) and 2 °C temperatures (in a range of from 16 to 30 °C). He then plotted the weighted mean daily growth rates as a function of temperature and tail size. He observed a curvilinear pattern which he fitted statistically to the following equation:

$$G = b_0 + b_1 L + b_2 L^2 + b_3 T + b_4 T^2 + b_5 LT$$

where b is the instantaneous growth rate in mm tail/d, L is the tail length in mm, T is the average temperature of the water which the shrimp were assumed to inhabit during growth, and the b's are statistical parameters which describe how growth is affected by the variables.

Solutions to his sex specific equations are plotted in Figure 22. Within the 45 to 110 mm tail length and 16 to 30 °C temperature constraints of his data, Nichols' equation for female white shrimp predicts that maximum daily growth rates of 0.39 to 0.42 mm occurs at 30 °C for females of 60 to 85 mm tail length. For female shrimp smaller than 85 mm tail

length, daily growth is predicted to decline with decreasing temperatures, the decline being more steep with the smallest females of this range. Though growth rate of all females declines as temperature declines, the size or sizes of shrimp exhibiting the maximum observed growth for a given temperature below 30°C increases. For example at 25°C, the maximum growth rate is 0.35 to 0.37 mm/d for females in the 80 to 95 mm tail length range. At 16°C the maximum growth is 0.21 - 0.23 mm/d for females larger than 100 mm tail. By contrast, at 16°C females less than 75 mm are either not growing or growing at a reduced rate of 0.02 mm/d.

For male white shrimp, within the same 45 to 110 mm tail length and 16 to 30°C temperature constraints of his data, Nichols equation predicts that males will have a slightly higher maximum daily growth than females. This maximum, 0.42 to 0.44 mm tail/d also occurs at 30°C for males of a similar size range, 55 to 85 mm tail length. Daily growth is predicted to decline with decreasing temperature, the decline being more steep with the smallest males. As with female white shrimp, as the growth rate declines from this temperature related maximum, the size or sizes of shrimp exhibiting the maximum observed growth for a given temperature increases. At 25°C, the maximum growth rate is 0.32 to 0.35 mm/d for males in the 70 to 100 mm tail length range. (This maximum is slightly less than for females at this temperature, but is over a wider (though similar) size range. At 16°C the maximum growth is 0.22 mm/d for males larger than 105 mm tail length, while males less than 65 mm tail length are not growing or not growing at a rate greater than 0.02 mm/d. A pattern, again, strikingly similar to female shrimp.

From a management or prediction view point the very similar growth rate patterns predicted by Nichols' equations for males and females are reassuring, given the number of observations which he had to delete because of the presumed measurement errors. On the other hand, it is noteworthy that penaeid shrimp are expected to exhibit sex-specific growth rates, with females obtaining a larger maximum size (e.g. Parrack 1978, 1981). Evidently the shrimp in Nichols data set had not attained a maximum length and therefore, may not yet exhibit sex-specific growth rates. Given the visual similarities in the two growth rate equations and the many missing cells in the data, it should be worthwhile to rerun Nichols analysis testing for a significant effect of sex. If there is not a significant effect of sex, then the data can be pooled and refit to Nichols model, thus decreasing the number of cells with missing values and increasing the number of observations used to generate the equation.

Pink Shrimp

There are no published growth equations for pink shrimp in the northern U.S. Gulf. All of the reports

listed below are for the Dry Tortugas fishery in Florida.

Higman et al. (n.d.) determined the growth of postlarval-juvenile pink shrimp held in enclosures in the estuarine area of Everglades National Park. Multivariant regression analysis was used to determine significant relationships between weekly growth rate estimates and weekly estimates of bottom salinity, temperature, and dissolved O_2.

Shrimp in the October to April experiment exhibited a 16 mm increase in carapace length over 24 weeks, while those in the August to March experiment exhibited a 17 mm increase over 29 weeks. Three degree polynomial equations were fitted to the data,

for October to April

$$L_c = 1.08 + 0.66t - 0.0149t^2 + .0005T^3$$

for August to March

$$L_c = 0.52 + 1.54T - 0.068T^2 \ 0.0012T^3$$

where L_c is carapace length and T is time in weeks.

To test for environmentally induced variances in growth, Higman et al. derived a growth function which was "not a function of time." Salinity was significantly related to the growth function in both experiments: the growth function decreased with increasing salinity. Theoretically, no growth was expected above 22 ppt in the first, 26 ppt in the second experiment. Salinities varied in the first experiment from 10 ppt to 22 ppt and in the second from 11 ppt to 29 ppt. Since the salinity regime of this area is dependent upon drainage through southern Florida into the Everglades, pink shrimp success in the Dry Tortugas may be related to local rainfall in the Everglades drainage basin as well as to man-made alterations which block the normal waterflow patterns.

The growth function was significantly related to temperature only in the second experiment where it decreased with a decreasing temperature to 19° C where no growth was theoretically expected. The authors suggest that the apparent discrepancy in temperature dependence may be related to the fact that temperature was lower and less variable in the first than second experiment.

Iverson and Idyll (1960) tagged pink shrimp in the Dry Tortugas in December 1957 and recovered them through April 1958. Females increased from 39 to 31 tails per pound in 45 days, whereas males increased from 60 to 50 tails per pound in the same time. This approximate growth rate of 0.7 g per week for female shrimp and of 0.38 g per week for male shrimp. The authors cautioned that these estimates were made in the "unusually cold winter of 1957-1958 and may be slower than the growth in a more normal winter."

Kutkuhn (1966, Table 4) estimated that pink shrimp tagged in the Dry Tortugas area September to December 1961 grew from 5.9 g to 19.5 g in 12 weeks. He derived a von Bertalanffy equation to describe his growth data,

$$W_t = 42 = (1-e^{-.071(t-.68)})$$

where W_t is weight in g at time t in weeks.

Lindner (1966) derived growth curves for pink shrimp in the Dry Tortugas. His equations are

$$L_t = 185 \text{ mm } (L\text{-}e^{-.068(t)})$$

$$W_t = 57.8 \text{ g } (L\text{-}e^{-.068(t)})^3.$$

Mortality Rates

The death of fish in a population is considered to be due either to natural causes or to harvest by man. Coefficients of fishing (F), natural (M), and total (Z) mortality are defined as instantaneous death rates for a cohort of N individual fish over a short time, dt. A simple differential equation is usually assumed to apply:

$$N = N_o e^{-Zt}$$

$$= N_o e^{-(F+M)t}$$

where N_o = initial number of fish (Gulland 1974).

The reported estimates of natural (M), fishing (F), and total (Z) mortality of shrimp exhibit a wide range of values. These are compared in Table XXX. Values of the instantaneous natural mortality rate on a monthly basis range from .01 to .55 or a loss of from one to 42 percent of the population from the beginning to the end of the month. Estimates of fishing mortality range from .02 to 2.0 (Iverson 1962; Klima 1964, 1974; Klima and Benign 1965; Kutkuhn 1966; Lindner 1966; Beng 1967; Costello and Allen 1968; Berg 1970; Nance 1991)

Because these wide ranging estimates of natural mortality have made construction of yield per recruit models difficult, considerable scientific attention has been devoted to selecting a scientifically sound reduced range. The most recent scientific evidence suggests that the accepted range of M for brown, white and pink shrimp lies between 0.2 to 0.35 on a monthly basis, with a midpoint value of 0.275 (Nance 1991).

Yield per Recruit

The pounds of brown, white, or pink shrimp which can be harvested from a given number of post larval shrimp reaching an estuarine system is a function of the population's rates of growth and natural mortality, the age at which harvest begins, and the rate of fishing mortality once the shrimp are subject to harvest. The age at which yield (in pounds) will be maximized is dependent on the trade off between the rates of growth and of natural and fishing mortalities, while the age at which exvessel value is attained is a function of these parameters and the current price structure. For purposes of this plan, it is important to remember that maximum yield is not attained with maximum economic benefit.

Brown Shrimp

For the purposes of this plan we constructed a Ricker type (Ricker 1958) yield per recruit model using Parrack's

(1981) sex specific growth rate equations, his non sex-specific length-weight equation and Bruenmeister's (1981) sex-specific tail weight to whole weight equations. Size at entry into the fishery was varied from 150 to 20 whole shrimp per pound in intervals of 10. (The 10 count interval was not obtained by male brown shrimp after two years of growth according to Parrack's equation and so was not used in our analysis.) Once shrimp were recruited to the fishery they were allowed to live for two years or until their numbers fell below 1 shrimp. Shrimp were fished on a .01 month basis with fishing mortality (F) being applied at the middle of each .01 month time step to more closely approximate a continuous exponential decline. Three levels of natural mortality were investigated: the midpoint and the upper and lower extent of the accepted range of values (Nance et al. 1991). Results, expressed in terms of the theoretical maximum annual yield, are plotted in Figures 23a-23c. For purposes of discussion we define the current fishery as having a F which varies from 1.0 to 2.0 on an instantaneous monthly basis, a size of entry of 100 brown shrimp to the pound (an age of 2-months in Parrack's equation). Since some shrimp are actually recruited to the fishery at a smaller size, all of our yield comparisons are minimal (and therefore conservative) estimates of increases over current harvest strategies. Though at any specific age females and males will differ in their expected weights, for purposes of discussion the average count of male and female shrimp at a given age is used below.

The current fishery is operating at 58 to 89% of the maximum yield (Figures 23 and 24). The lower end of this range of values is defined by a F of 2.0 and a M of 0.20. The upper end is defined by a F of 1.0 and a M of 0.35.

While the specifics of each plot are discussed below in the following subsections there are some very important generalizations which transcend the current uncertainty over the rate of natural mortality. These are discussed first in terms of potential losses which would be the indirect result of no action by management. Following this, potential gains are discussed which would require regulations. This discussion proceeds first with poundage and then with exvessel value.

First, given that the size at entry remains at 100 count, any increase in fishing mortality above and within the current range of F results in a decrease in yield per recruit (Figures 23a-23c). That is, at 100 count entry, any increase in fishing mortality above 1.0 results in a lower harvest poundage. Within the current levels of F, this decrease is not precipitous, but is on the order of 5 to 9% of the maximum yield as F increases from 1.0 to 2.0 on a monthly basis, and size at entry remains 100 count. (As will be true throughout this discussion, the range in the percentage change is a reflection of the range in accepted levels of natural

mortality and the observed variance in fishing mortality over a range of 1.0 to 2.0.) Any increase in F above a level of 2.0 will continue this trend.

At the current levels of fishing mortality, decreases in yield are predicted if the size of first harvest declines to sizes less than that producing 100 count (Figures 23a-23c). Within the 100 to 150 count window, these declines are not precipitous. The maximum declines occur at 150 count and are on the order of 9 to 13% of the maximum yield per recruit. Any declines in size of harvest below 150 count will continue this trend, which at some point will become precipitous, even without a consideration spawner-recruit overfishing.

At the current size at entry (100 count), increases in yield are predicted for limited reductions in fishing mortality below a level of 1.0 (Figure 23). These increases are not great but on the order of 1 to 10% of the maximum yield, with the maximum increases occurring at F's of 0.4 (for a M of 0.2) and of 0.7 (for a M of 0.35).

At the current levels of fishing mortality, increases in yield per recruit are predicted for all or most sizes at first harvest at which shrimp are larger than 100 count (Figures 23a-23c). The potential level of this increase may or may not be great, depending on the level of natural mortality. At the upper end of the accepted range of M (0.35) the maximum expected increase is 11% of the maximum yield (Figure 23a). At the lower end of the accepted range of M (0.20) the maximum predicted increase is 29% of the maximum yield (Figure 23c). On the other hand, maximum yield can only be obtained with sizes of first harvest which essentially eliminate a large component of the present industry because of their gear. Such unilateral allocations of adverse impacts are not allowed under the FCMA.

Maximum harvest strategies which are consistent with the FCMA all involve reductions in F and, at some levels of M, increases in size at first harvest by 10 or 20 count.

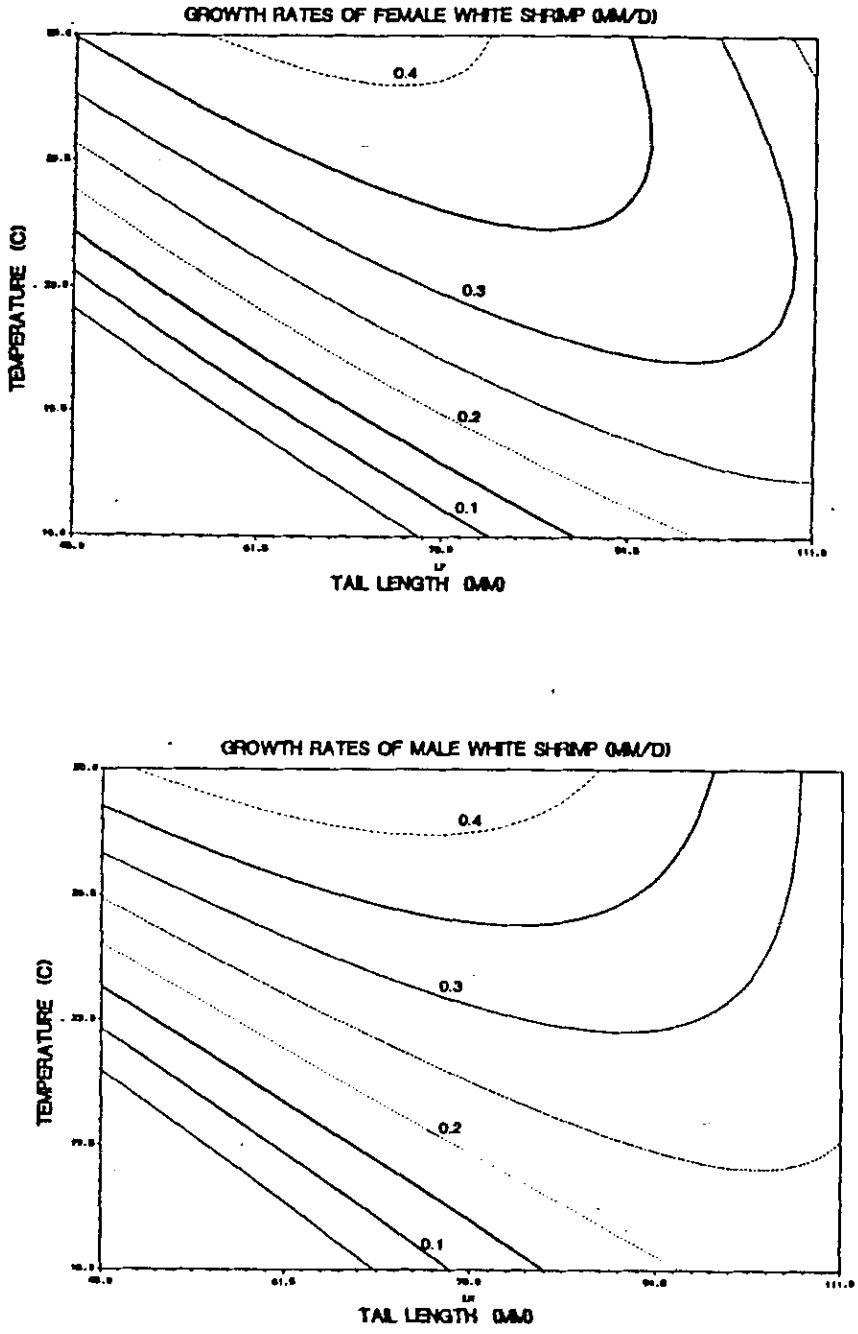


Figure 22. Growth rate of female (a) and male (b) white shrimp in mm tail length per day as a function of size (in mm tail length) and temperature (after Nichols 1981)

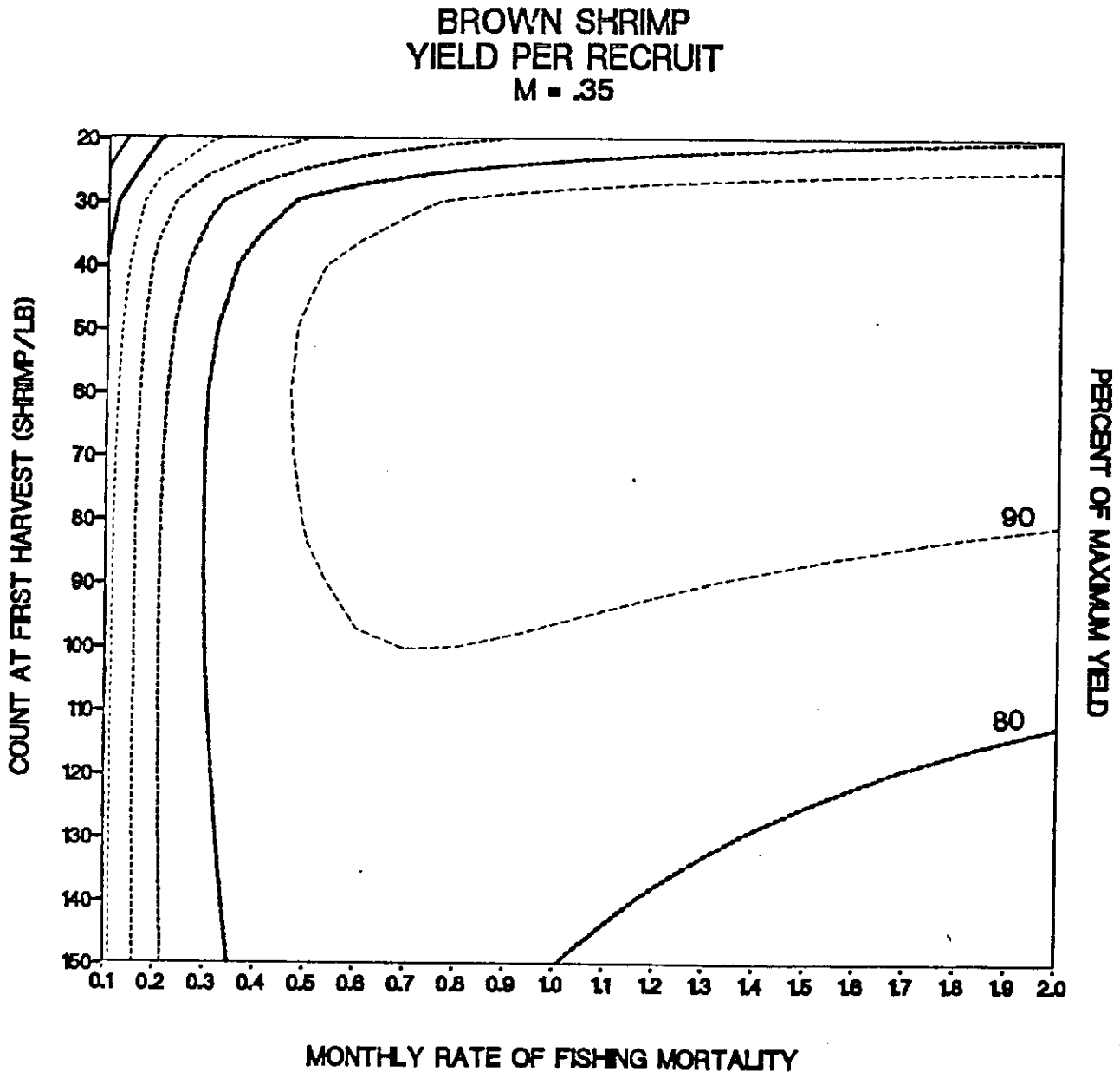

BROWN SHRIMP
YIELD PER RECRUIT
M = .35
COUNT AT FIRST HARVEST (SHRIMP/LB)
20
30
40
50
60
70
80
90
100
110
120
130
140
150
90
80
PERCENT OF MAXIMUM YIELD
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
MONTHLY RATE OF FISHING MORTALITY

Figure 23a.

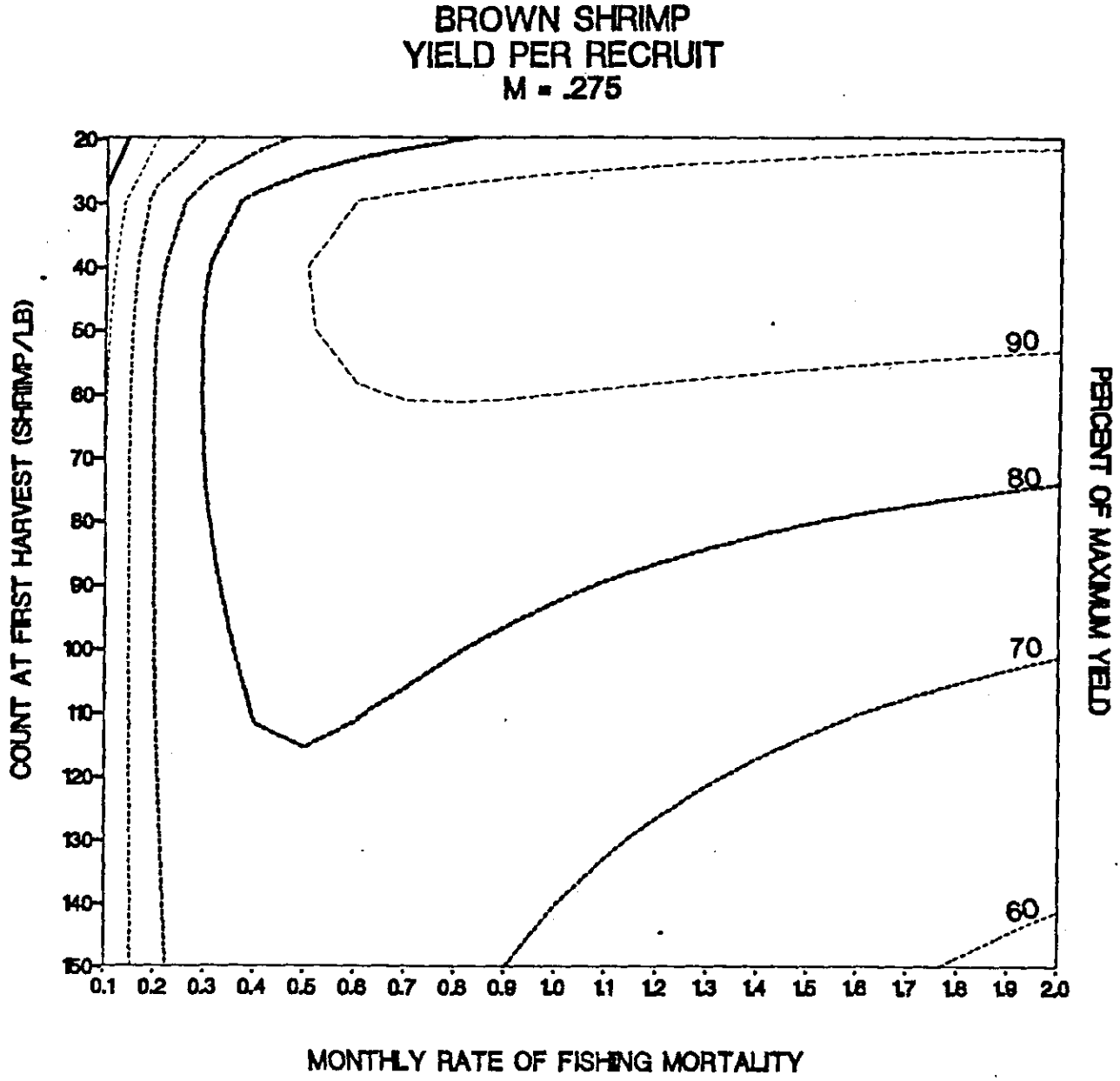


Figure 23b Yield per recruit contours for brown shrimp expressed at the percent of the theoretical maximum yield when fishing begins at different count sizes (number of whole shrimp per pound) ranging from 150 to 20 count. Yields are considered for three levels of instantaneous monthly natural mortality: a) 0.275, the mid point of the accepted range, b) 2.20, the lower extent of the accepted range, and c) 0.35 the upper extent of the accepted range

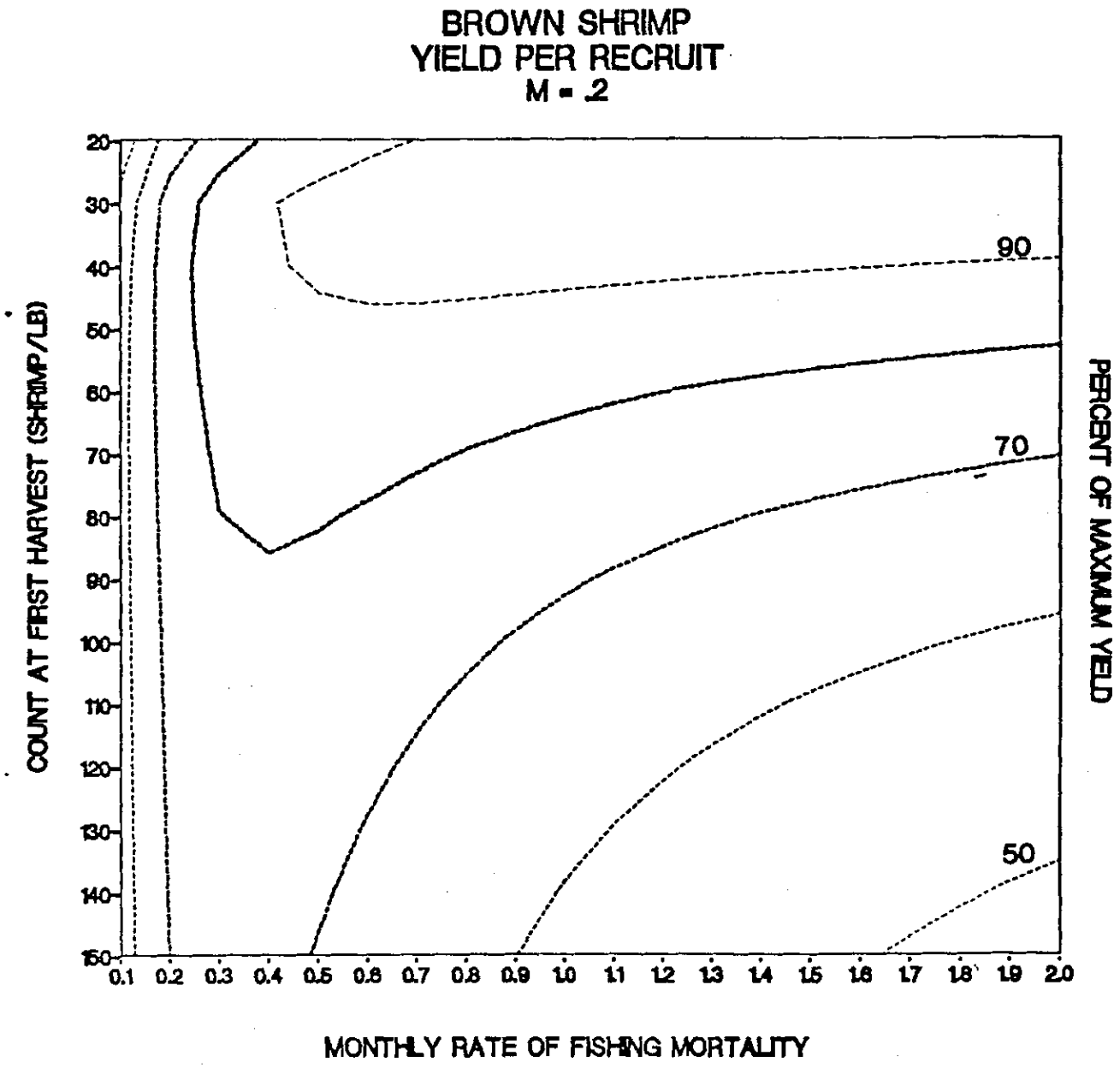

BROWN SHRIMP
YIELD PER RECRUIT
M = .2
COUNT AT FIRST HARVEST (SHRIMP/LB)
20
30
40
50
60
70
80
90
100
110
120
130
140
150
90
70
50
PERCENT OF MAXIMUM YIELD
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
MONTHLY RATE OF FISHING MORTALITY

Figure 23c.

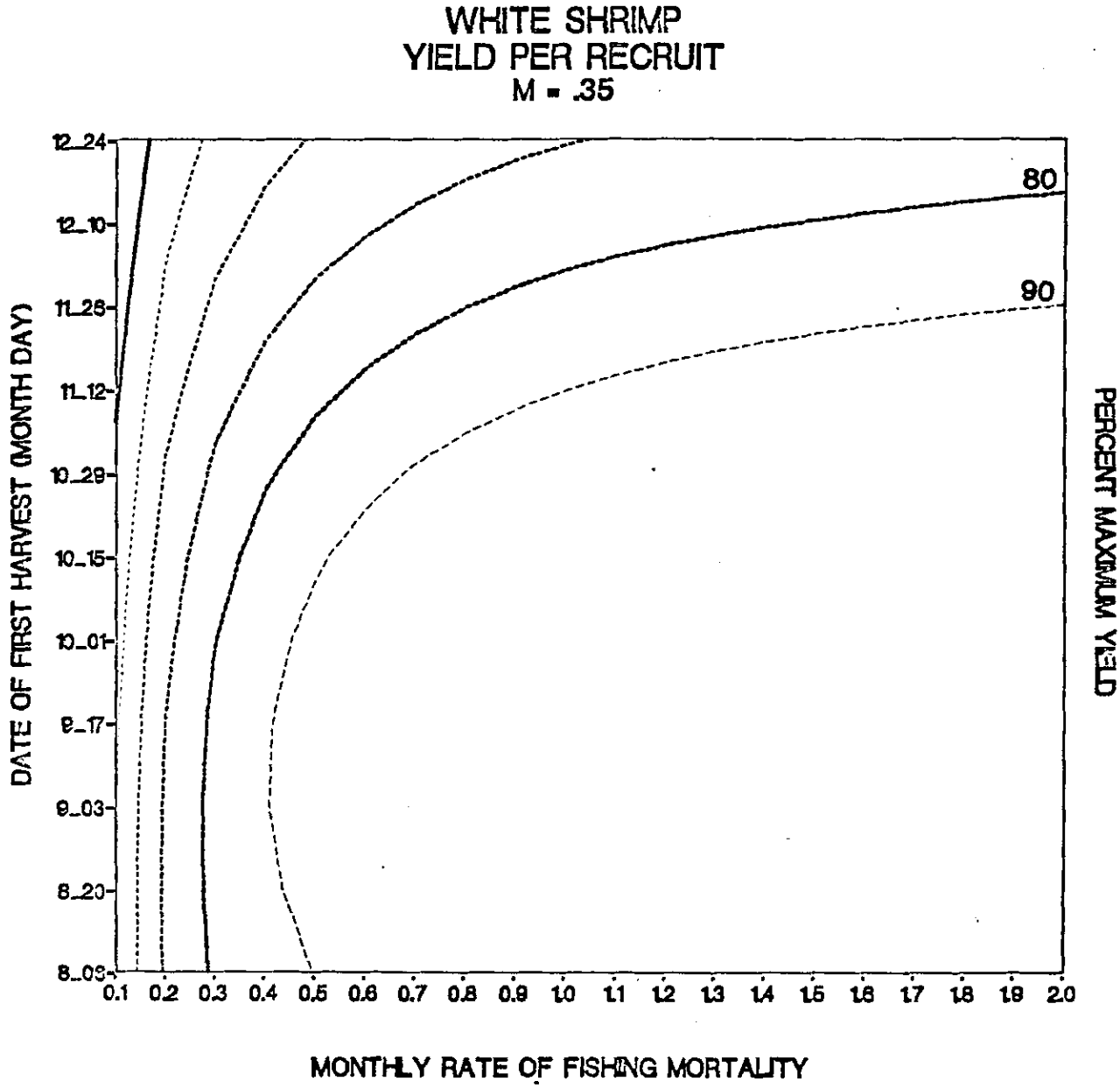

WHITE SHRIMP
YIELD PER RECRUIT
M = .35
12_24
12_10
11_26
11_12
10_28
10_15
10_01
9_17
9_03
8_20
8_06
DATE OF FIRST HARVEST (MONTH DAY)
80
90
PERCENT MAXIMUM YIELD
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
MONTHLY RATE OF FISHING MORTALITY

Figure 24a.

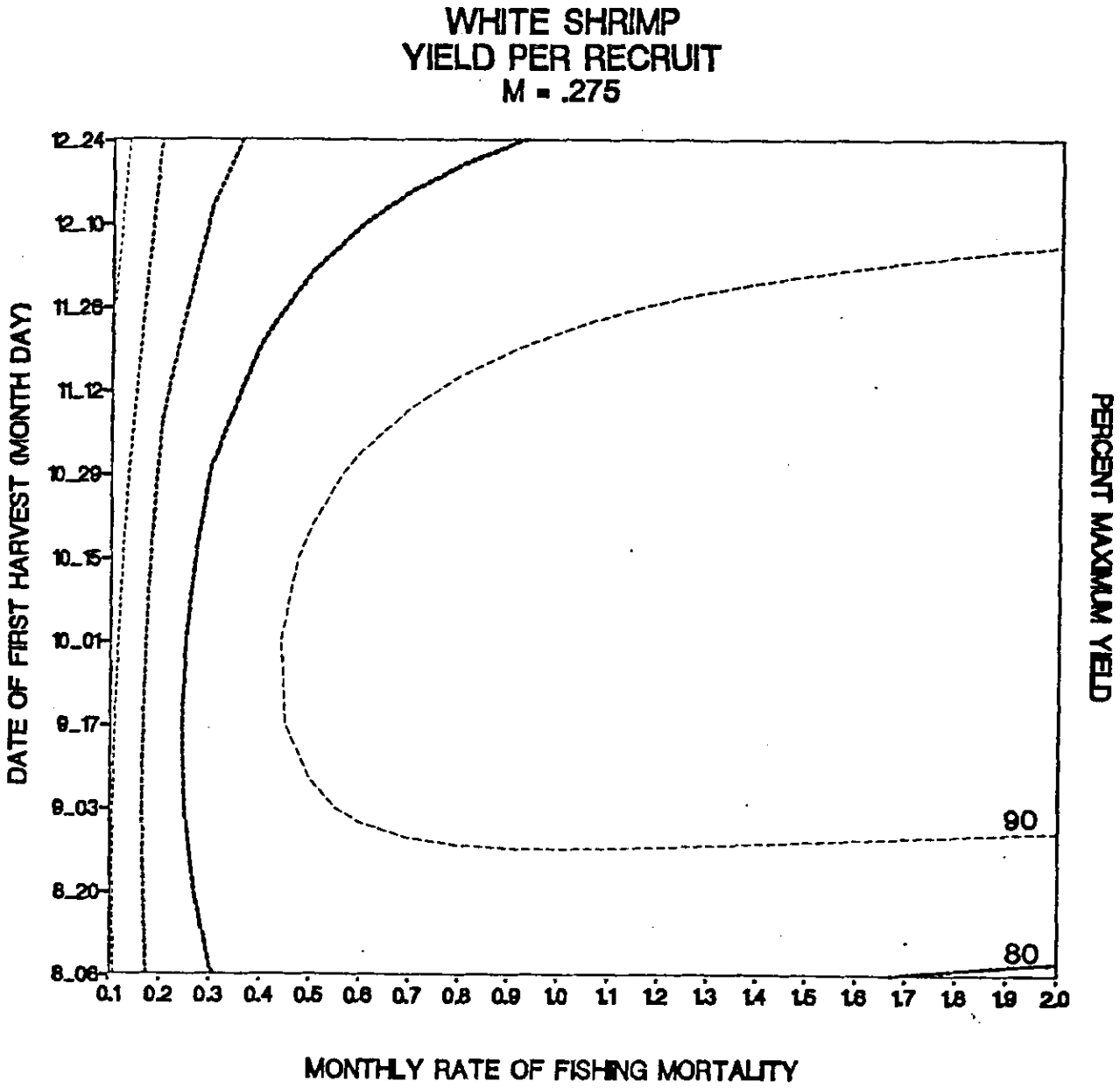


Figure24b .Yield per recruit contours for white shrimp expressed at the percent of the theoretical maximum yeild when fishing begins at different opening dates. Yields are considered for three levels instantanious monthly natural mortality: a) 0.275, the midpoint of the accepted range, b) 0.20, the lower extent of the accepted range, and c) 0.35 the upper extent of the accepted range.

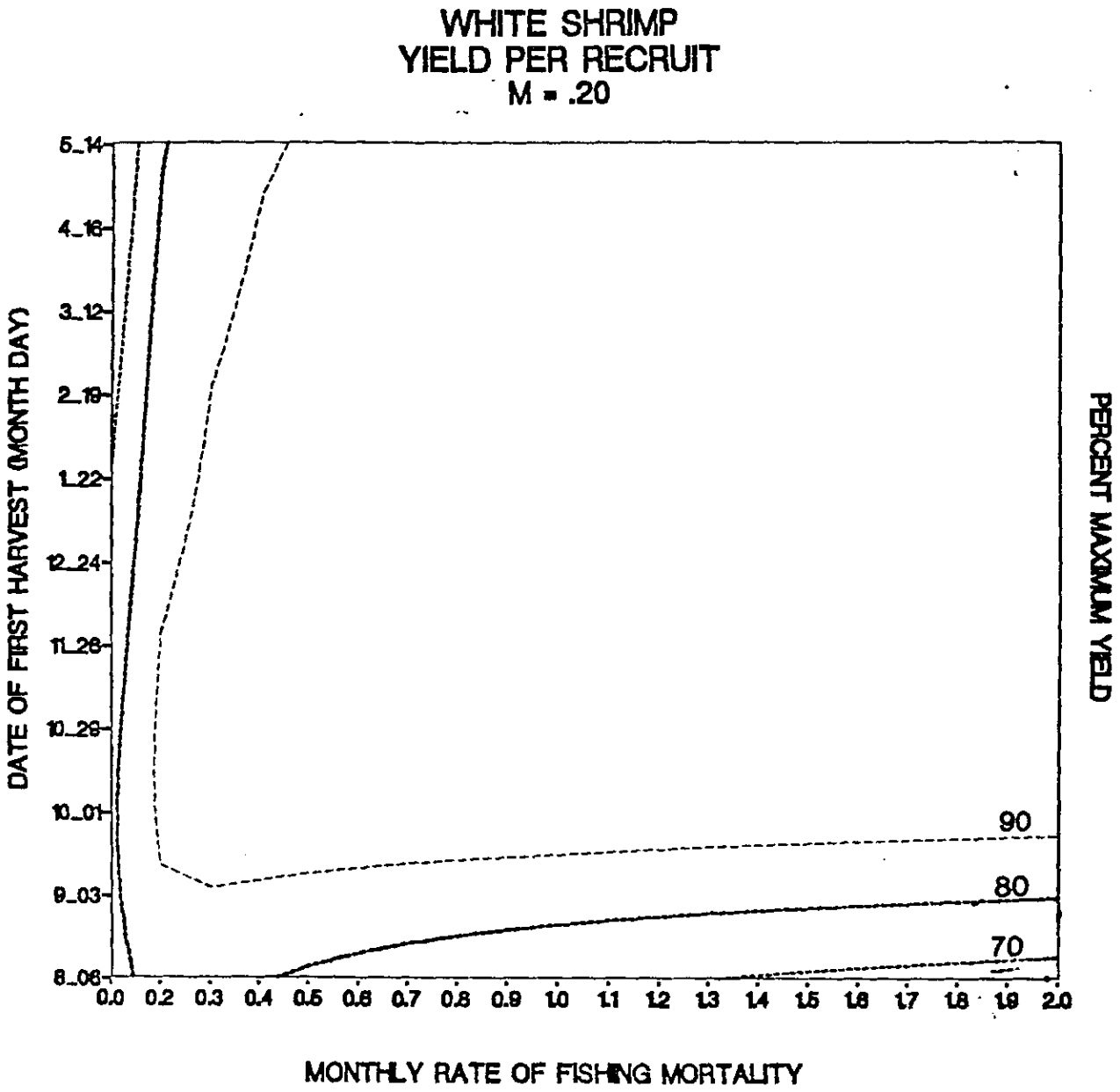

WHITE SHRIMP
YIELD PER RECRUIT
M = .20
DATE OF FIRST HARVEST (MONTH DAY)
5_14
4_16
3_12
2_18
1_22
12_24
11_26
10_26
10_01
9_03
8_06
0.0 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
MONTHLY RATE OF FISHING MORTALITY
PERCENT MAXIMUM YIELD
90
80
70

Figure 24c.

Chapter 6 - Economic Assessment

Louisiana's shrimp fishery is complex. As the shrimp grow and migrate offshore, they become the target of several different and to an extent, distinct, user groups. Also, they become more susceptible to capture by out-of-state shrimpers as they move to Federal waters, according to the National Marine Fisheries Statistics.

Adding to the complexity of the fishery is a processing sector that depends on a wide range of shrimp sizes. Peelers, for example, require a smaller shrimp than processors selling a raw-headless product; processors of other processed shrimp products may require even a smaller sized shrimp.

Yet another element adding to the complexity of the Louisiana shrimp fishery is the import situation. Increased imports have depressed the real shrimp price at both the consumer and producer level. Imports of processed shrimp, especially peeled, appear on the rise originating mainly from Asia where most of the growth in shrimp supply is expected.

Management of Louisiana's shrimp fishery is a complicated process and all of the above factors must be considered when developing a management strategy, if economics is used in the management framework. Decisions will have to be made even in cases where data may be less than desirable. Some weaknesses in the data have been layed out in other sections of this plan and others undoubtedly exist.

Given the complexity of Louisiana's shrimp fishery and its diversity of user groups, any significant management measures will involve tradeoffs. Some groups may benefit from the management measures but others likely will not. The study of economics, by its nature, is the study of trade-offs.

Before the trade-off can be properly assessed from an economic perspective it is fundamental to state the management goal in a very concise, well-defined manner. Goals such as "maximizing economic benefits", for example, are so all-inclusive that they are of little benefit in developing a management strategy. For instance, what benefits do you wish to maximize: (a) employment, (b)

dockside revenues, (c) profits to the fishermen, (d) the total value to the fishery including all value-added activities, (e) some combination of the aforementioned factors, or (f) some other component? Furthermore, for whom do you wish to maximize benefits: the citizens of Louisiana; participants in the shrimp fishery; a specific segment of the industry? All of these benefits cannot be maximized simultaneously.

While models exist to help analyze these "trade-offs", any model, by definition, is only as good as the data that goes into developing it. In the Louisiana shrimp fishery situation, data deficiencies are apparent. So while models can help access some potential "trade-offs", they should not be considered a substitute for the expertise by the individuals who work in the fishery and understand its inner workings.

This said, the information provided throughout this chapter can help provide guidance in assessing potential "trade-offs" associated with various management strategies. Management measures that would provide for a significantly larger size of shrimp at capture, for instance, could be associated with at least four "trade-offs". First, the role of the small boat shrimpers may be lessened while the role of the larger boat shrimper may be enhanced. Second, the peeling and "other" components of Louisiana's shrimp processing sector may be lessened while the role of the raw-headless component will likely be enhanced. Third, out-of-state shrimp boats may take an increased share of total catch, assuming the increased size at capture allows increased movement of shrimp into Federal waters. Finally, while increased size at capture may result in increased dockside value of the catch, it may not result in increased total value attributable to the fishery when loss of processing and other activities are considered.

Harvest Value

Total Ex-vessel Value and Price

The value of Louisiana's shrimp landings at dockside increased from an average of $40 million annually in 1970-74 to $161 million in 1985-89 and equalled $153 million in 1990 (Table XXXI; Figure 25). The value of landings in 1986, exceeding the two-hundred million dollar mark, was a state record.

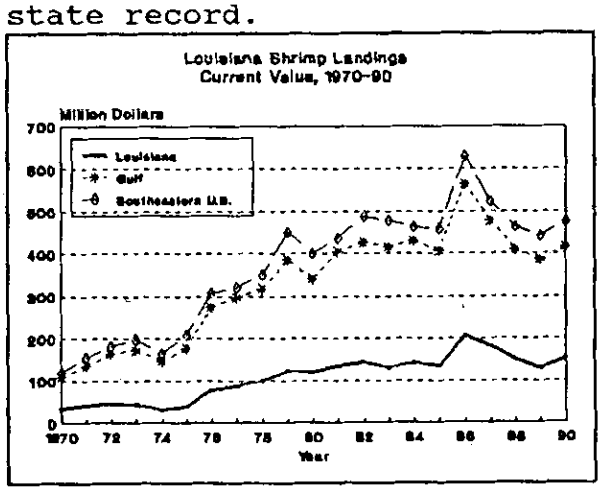


Figure 25

In the Gulf Region, the value of shrimp landings expanded from $146 annually in

1970-74 to $449 million annually in 1985-89. Total U.S. warm-water landings, i.e. Gulf and South Atlantic landings, grew from $165 million annually to more than one-half billion dollars annually during the same period of analysis (Table XXXI; Figure 25). Because of increased pounds landed in Louisiana relative to the Gulf Region and Southeast total, Louisiana's share of Gulf Region and total Southeast dockside shrimp value expanded. In 1970-74, for instance, Louisiana's landings represented 28% of the Gulf Region dockside value and almost a quarter of the total Southeast value at dockside. By 1985-89, Louisiana's share had increased to about 36% of the Gulf Region and almost a third of the total Southeast.

Louisiana's increased dockside shrimp value during 1970-90 was the result of two factors. First, as previously noted, the state's shrimp landings as measured in pounds increased significantly during the 21 year period ending in 1990. Second, Louisiana's dockside shrimp price increased during 1970-90. As shown in Table XXXII and Figure 26, the dockside price for Louisiana's shrimp landings grew rapidly during the 1970s, peaked at $2.68 per headless pound in 1983, and has since fallen sharply. The 1990 price of $2.02 per headless pound was only 75% of the 1983 price.

Much of Louisiana's increased dockside shrimp price and related value during the 1970s and early 1980s was inflationary based. The Consumer Price Index measures

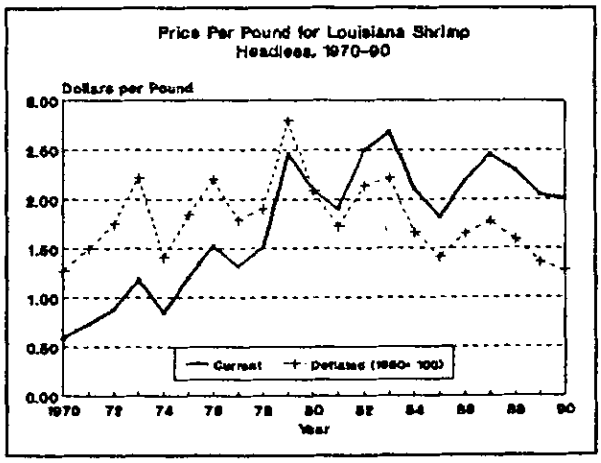


Figure 26

the rate of inflation throughout the United States economy. The change in Consumer Price Index during 1970-90 is given in Table XXXII, with 1980 serving as the base year, i.e., 1980 = 100. The choice of the base year is arbitrary since the measure of change is relative.

As indicated, the Consumer Price Index (CPI) increased from 0.471 in 1970 to 1.585 in 1990, an increase of over 300%. This indicates that, on average, it would cost three times as much to purchase the same goods and services in 1990 as in 1970. As such, it is important to evaluate dockside price and value after removing the effects of inflation. This can be accomplished by dividing prices (value) by the CPI for the corresponding year. This provides an expression for prices (value) on a deflated, or real, basis.

As indicated in Table XXXII and Figure 27, the deflated dockside price of shrimp landed in Louisiana peaked in the late 1970s and has since fallen steadily.

The average annual 1985-89 deflated price of $1.57 per headless pound is below that observed during 1970-74 and the 1990 deflated price of $1.28 is nearly identical to the lowest price observed during the 21 year period ending in 1990; that being $1.27 per headless pound in 1970.

Two reasons can be advanced for the decline in Louisiana's dockside shrimp price. First, shrimp imports increased rapidly during the 1980s. These increased imports have significantly impacted the deflated dockside price of shrimp throughout the Southeast, according to Keithly et al.(in press) A second reason for the decline in deflated dockside price relates to the increased proportion of >67 headless count shrimp being landed in Louisiana during the 1980s (Table IX). The impact of this latter factor, however, is probably minor in relation to impact related to increased imports.

Evaluated on a deflated basis, the value of Louisiana's shrimp landings has changed little since the late 1970s (Table XXXIII, Figure 27). This stability has occurred, despite the sharp decline in the deflated price of the landed shrimp, as a result of higher production in poundage during the 1980s. Overall, the deflated value of Louisiana's shrimp landings in 1985-90, averaging $117 million annually, exceeded the comparable figure for 1970-74 ($78 million) by almost 50%, but was marginally above the comparable figures for the 1975-79 period ($113 million). The deflated values in both 1989 and 1990 are the lowest dating back to 1975.

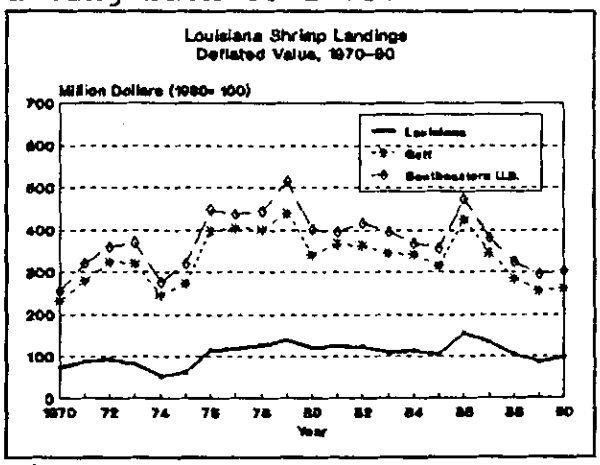


Figure 27

As noted in reference to Table VIII, Louisiana's shrimp landings, as measured in pounds, typically exceeded those reported in any of the other Gulf Region states. By value at dockside, however, Louisiana's shrimp landings rank second behind Texas, due to the higher price received for the Texas landed product (Table XXXIV). In fact, Louisiana's dockside shrimp price, on a per pound basis, is the lowest among all of the Gulf Region states. In 1985-89, Louisiana's annual dockside shrimp price averaged 69% of that reported for Florida, 61% of that reported for Alabama, 75% of that reported for Mississippi, and 66% of that reported for Texas. The lower price received for Louisiana shrimp reflects a smaller shrimp size at harvest.

Value by Size

Tables XXXV and XXXVI give the current and deflated values of Louisiana's shrimp landings, by size of shrimp, for the

1970-90 period. For purposes of discussion, they are analyzed on the basis of three categories: <31 count headless shrimp to the pound, 31-67 count headless shrimp to the pound, and >67 headless count shrimp to the pound.

<31 Count (headless)

The current value of <31 count Louisiana shrimp landings averaged $31 million annually in 1985-89 compared to $16.5 million in 1970-74, an increase of almost 90%. Most of this increase was inflationary based. When examined on a deflated basis, the value of Louisiana's <31 count headless shrimp landings increased less than five percent between 1970-74 and 1985-89, from $32 million annually to $33 million. The deflated value of these landings peaked in 1975-79 at $42 million annually.

Shrimp in the <31 count range represented 41% of Louisiana's landings by value in 1970-74 (Table XXXV), while comprising 21% of the poundage (Table IX). This difference reflects the higher price received at dockside for the larger shrimp, as illustrated in Figure 28 (current price) and Figure 29 (deflated price).

Since the 1970-74 period, the contribution of <31 count headless shrimp to the total value of Louisiana's shrimp landings has declined from 37.6% in 1975-79 to 25.5% in 1990. This decline reflects the noted change in contribution to the state's landings represented by shrimp in the <31 count range.

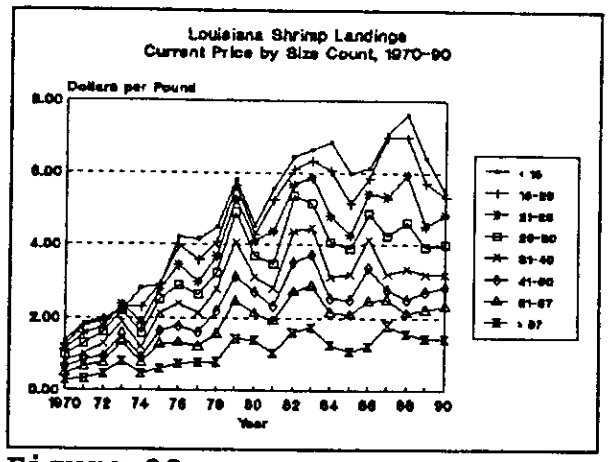


Figure 28

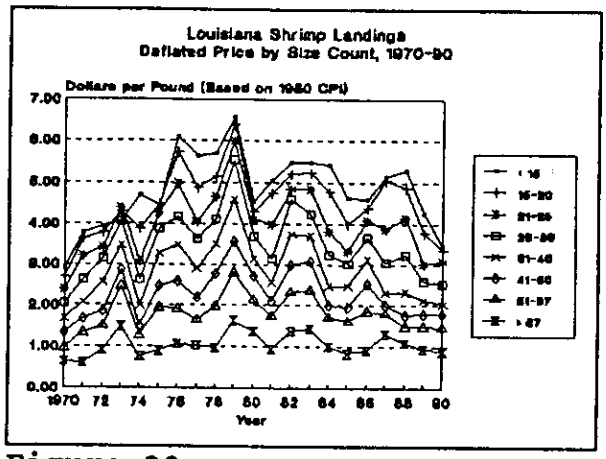


Figure 29

The deflated price of shrimp in all size counts less than the <31 count category, in general, increased during the 1970s and decreased during the 1980s (Figure 29). For example, the deflated price of <15 count shrimp averaged $5.71 per pound in 1975-79 compared to $4.74 per pound in 1985-89, and $3.44 per pound in 1990. The deflated price of 15-20 count shrimp averaged $5.30 per pound in 1975-79 compared to $4.37 in 1985-89. Shrimp in the 21-25 and 26-30 count range received, on average, prices

(deflated) of $4.78 and $4.23, respectively, at dockside in 1975-79. By 1985-89, their prices had fallen to $3.76 and $3.17, respectively. Deflated prices in these counts in 1990 equalled only $3.07 and $2.53.

31-67 Count (headless)

Shrimp in the 31-67 category accounted for 32%-36% of Louisiana's landings by value during 1970-90, when evaluated in five-year intervals. With the exception of 1990 data, there appears to be little change in the contribution to the state's dockside shrimp value represented by landings in the 31-67 category. This was also the case with respect to pounds landed in this category. (Table IX)

The current value of shrimp landed in the 31-67 category grew from $13 million annually in 1970-74 to $54.5 million annually in 1985-89 and equalled $42 million in 1990. Even after removing the effects of inflation, the value of Louisiana's shrimp landings in this size category increased by almost 60% between 1970-74 and 1985-89, from $25 million annually to $40 million annually. (Table XXXVI)

>67 Count (Headless)

The share of Louisiana's dockside shrimp value represented by landings in the >67 category expanded from 26% in 1970-74 to 37% in 1985-89 and equaled 47% in 1990. They equalled, by comparison, 60% of the state's production in poundage in 1985-89 and 68% in 1990. The current value of these landings for the same period increased from 10 million annually to $58 million in 1985-89 and equalled over $70 million in 1990. Evaluated on a deflated basis, the value of Louisiana's shrimp landings in the >67 category more than doubled from just less than $20 million annually in 1970-74 to $42 million annually in 1985-89.

Value by Species

Table XXXVII provides information on the value of Louisiana's shrimp landings, by species, for 1970-90. As indicated, the current value of both brown and white shrimp landings gradually increased during 1970-90; with white shrimp consistently representing about 58% of the state's landings by value.

On a deflated basis, the value of both brown and white shrimp landings increased until the late 1970s to early 1980 and have remained relatively stable when evaluated in a five-year intervals. For example, the deflated value of brown shrimp landings in 1985-89, averaging $47 million annually, was less than three percent above that calculated for the previous five-year period ($45.9 million) and only about six percent above that reported in 1975-79 ($44.6 million). With respect to white shrimp landings, the average deflated annual value in 1985-89 ($67.3 million) was within one percent of average annual deflated dockside value in 1981-85 ($67.8 million) and only about two percent above that reported in 1975-79 ($65.9 million).

Value by Species by Size

The value of Louisiana's brown and white shrimp landings are given in Table XXXVII. In general, a greater proportion of the value of both Louisiana's brown shrimp and white shrimp dockside values appear to be in the >67 count shrimp in recent years. With respect to brown shrimp, 50% or more of the value of landings was represented by the >67 count range in seven of the ten years of the 1980s compared to only three of the ten years during the 1970s. Furthermore, >67 count brown shrimp accounted for more than 60% of the value of brown shrimp landings in three of the ten years in the 1980s compared to only one year of the 1970s. The increased proportion of the dockside value of brown shrimp landings in the ≥68 category is related to the increased proportion of landings represented by this size category (Table XIII).

During the 1980s, white shrimp landings >67 count to the pound exceeded 20% of the total value of white shrimp landings seven times and twice exceeded 30%. In the 1970s, white shrimp landings >67 count to the pound exceeded 20% just once. White shrimp landings <31 count to the pound exceeded 40% of the total value of white shrimp landings in only two of the ten years of the 1980s but did so in all ten years of the 1970s. In fact, ≤30 count white shrimp exceeded 50% of the total value of white shrimp landings in six of the ten years of the 1970s.

Value by Species, Size, and Month

The 1985-90 average current value of Louisiana's brown shrimp landings, by size and month is illustrated in Figure 30. Similar to pounds landed of the >67 count brown shrimp by month (Figure 7), the value of Louisiana's shrimp landings >67 count was minor until the opening of the brown shrimp season in late May or early June, peaked these two months, and then declined rapidly. The value of brown shrimp landings of 31-67 headless count to the pound peaked in June and July, remained sizeable in August, and then fell significantly until the following May. The value of Louisiana's brown shrimp landings <31 count peaked in August at close to three million dollars.

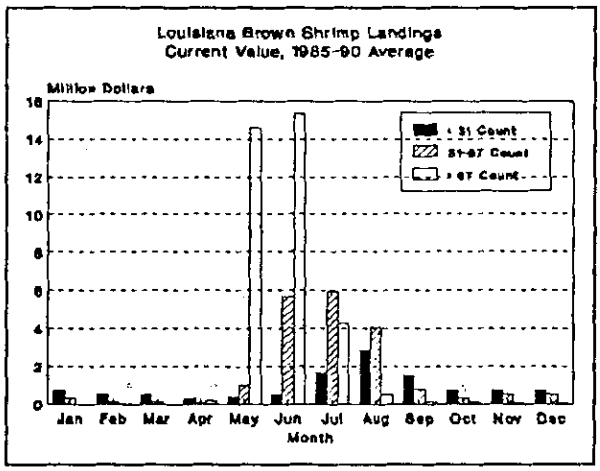


Figure 30

For the 1985-89 period, the average annual value of Louisiana's white shrimp landings in the ≥68 category showed a significant increase in August (associated with the opening of the fall season),

peaked at about $8 million in October, and declined steadily during the next several months (Figure 31). The value of white shrimp landings in the 31-67 category peaked two months earlier, in August, and then declined steadily throughout the remainder of the year. The value of white shrimp landings in the <31 category was highest in September and October but was also significant in May and June associated with the opening of the spring season. In all cases, the value of landings by size and month closely followed that reported for pounds landed.

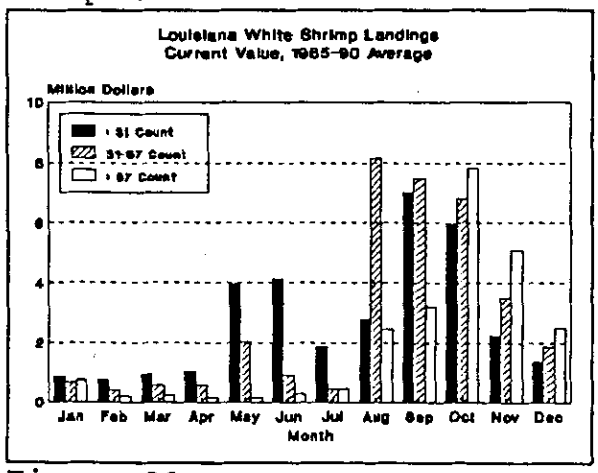


Figure 31

Value by Inshore/Offshore Waters

The current and deflated value of Louisiana's shrimp landings, by inshore and offshore waters, are provided in Table XXXIX. As indicated, the current value of Louisiana's shrimp landings from inshore waters nearly doubled between the 1976-80 and 1986-90 periods, from an annual average of $26 million to $52 million. The deflated value grew slightly more than ten percent, from $32 million to $37 million. The current value of landings of shrimp caught in offshore state waters increased from an average of $43 million annually in 1976-80 to $73 million annually in 1986-90. On a deflated basis, the value of landings of shrimp caught in offshore state waters equalled about $51 million annually in both the 1967-80 and 1986-90 periods.

The current landings value of shrimp caught in federal waters increased from an average of $33 million annually in 1976-80 to $40 million in 1981-85, and equalled $39.5 million in 1986-89. Evaluated on a deflated basis, the value of shrimp landings from federal waters declined steadily during 1976-90 when examined in a five-year periods, with the 1989 and 1990 deflated values both being the lowest on record dating back to 1976.

Reported landings of shrimp from Louisiana's inshore waters significantly underrepresent actual catch. This is also the situation with value. By bypassing traditional dealers and instead selling directly to restuarants and consumers, many part-time shrimpers were able to receive a higher per pound price for their catch, according to Keithly and Mounce (1990) This would indicate that underreporting of value exceeds that of poundage.

Overall, the proportion of the value of state landings represented by inshore state catch increased from 26% in 1976-80 to 32% in 1986-90. To a large extent, this increase

reflects the increased proportion of state landings in pounds harvested from inshore state waters (Table XV). On the other hand, the proportion of the value of state landings derived from state offshore catch remained relatively constant during 1976-90, when evaluated in a five-year intervals, while the proportion of the value of state landings represented by federal catch declined significantly. This decline reflects reduced landings from federal waters in relation to inshore state and offshore state waters.

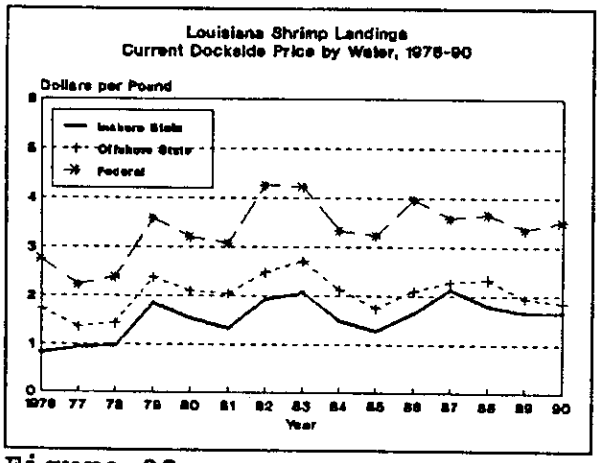


Figure 32

Current and deflated prices of shrimp landings from inshore state, offshore state, and federal waters are provided in Figures 32 and 33. As indicated, the price per pound of headless shrimp harvested in federal waters consistently exceeded that related to offshore state and inshore state, reflecting a larger harvest size shrimp. On a deflated basis, prices in all three cases peaked in the late 1970s or early 1980s and, since then, have declined considerably.

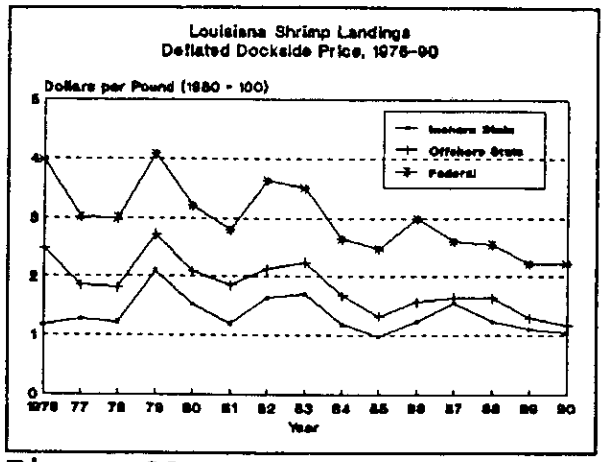


Figure 33

Catch Versus Landings

The dockside value of catch and landings from Louisiana's inshore and offshore waters is presented in Figures 34, 35 and 36. Since 1983, the reported dockside inshore catch has exceeded that of landings by $10 million to $20 million annually.

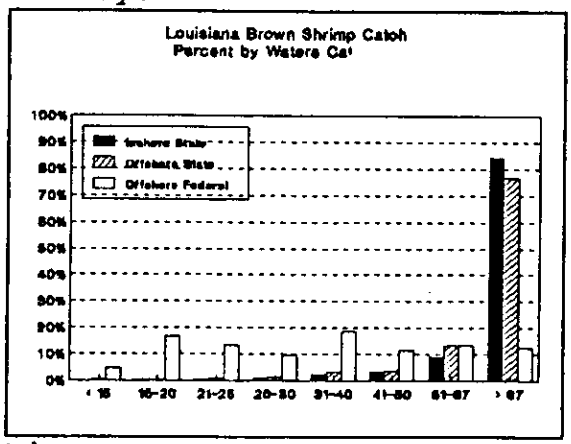


Figure 34

In state offshore waters, the value of catch exceeded that of landings by roughly the same amount as that noted for the inshore fishery.

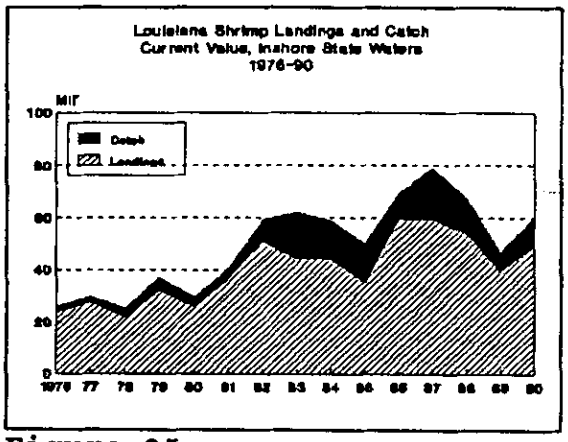


Figure 35

The value of catch from federal waters, however, often exceeded the comparable landings value by more than 70%. This reflects the substantial poundage caught in Federal waters off Louisiana that is landed in other states.

Value by Gear

The value and related price of Louisiana's shrimp landings by principal gears

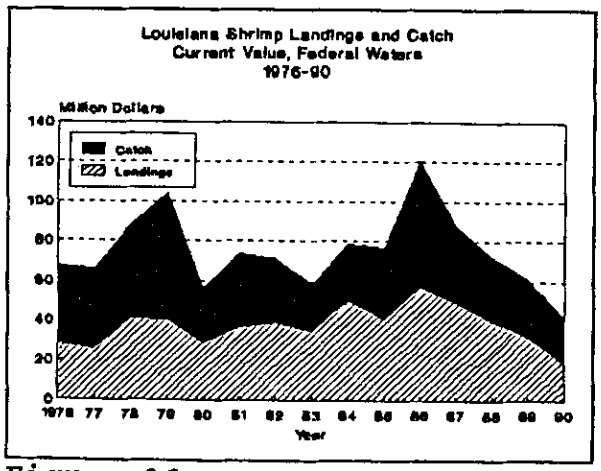


Figure 36

(trawls and wingnets) since 1985 are provided in Table XL. The value of catch from butterfly nets, generally accounts for 5%-10%, although unreported landings associated with this gear suggests that this range is extremely conservative. The price of shrimp landed by butterfly nets is considerably lower than that of trawls, largely due to the smaller size shrimp harvested with the butterfly nets.

Upon harvest, commercial shrimpers market their catch to dealers, processors, other intermediary buyers, or to the final consumer. These marketing activities are discussed below.

Income of the Fleet

Shrimping income is known to vary considerably from year-to-year. Factors affecting income include (a) the stock of shrimp available for harvest, (b) the average price of shrimp, (c) input costs (eg. fuel, insurance, etc.) and (d) the number of boats (vessels) harvesting from the fixed amount of shrimp.

In their 1987 study of Louisiana's shrimp fleet, Keithly and Mounce reported average net income of $11.3 thousand among full-time shrimpers of boats 20-30 feet, $9.8 thousand among full-time shrimpers of boats ≥30-50 feet, and $11.5 thousand among full-time shrimpers of boats ≥50 feet. These boats, however,

reflect only those that are inshore based during the inshore season.

In a 1978 study of Louisiana's vessels, Roberts and Sass (1980) report net income of $12.2 thousand for small (≤ 50 foot) vessels, and $46.5 thousand for large (≥65 feet vessels.

Though the studies by Keithly and Mounce (1990) and Roberts and Sass (1980) are not directly comparable for several reasons, the available information suggests that net returns from shrimping have declined during the past decade. This is consistent with the large increase in the number of boats fishing for the relatively fixed finite resource and the large decline in the deflated price of the shrimp catch.

No research has been conducted to examine fishing activities supplemental to shrimping. Louisiana Department of Wildlife and Fisheries license sales, however, can be used to help determine supplemental activities. In 1989, almost 79% of residents purchasing a shrimp gear license purchased no other fishing gear licenses. Almost 10% purchased a shrimp license in conjunction with another shellfish gear license. Almost seven percent purchased both the shrimp license and a finfish license. Finally, close to five percent of the residents purchased a shrimp license, another shellfish license, and a finfish license.

Processing

Value

The value of Louisiana's shrimp processing activities grew from an average of $70.5 million annually in 1973-75 to $141 million annually in 1985-87 before falling to $126 million in 1988-90. (Table XXIV; Figure 37) Much of the increase, was inflationary based. On a deflated basis, the value of Louisiana's shrimp processing activities peaked during 1976-78 at $250 million and has since fallen more than 45% to $133 million in 1988-90, based on the 1990 Consumer Price Index (Table XXIV; Figure 38). This reduction reflects a moderate decline in annual pounds processed and a larger

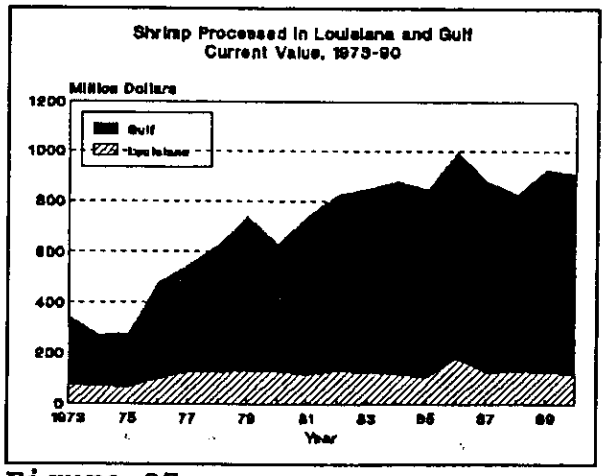


Figure 37

decline in the deflated processed price. The decline in processed price is related to the decline in the deflated dockside shrimp price. (Table XXXII)

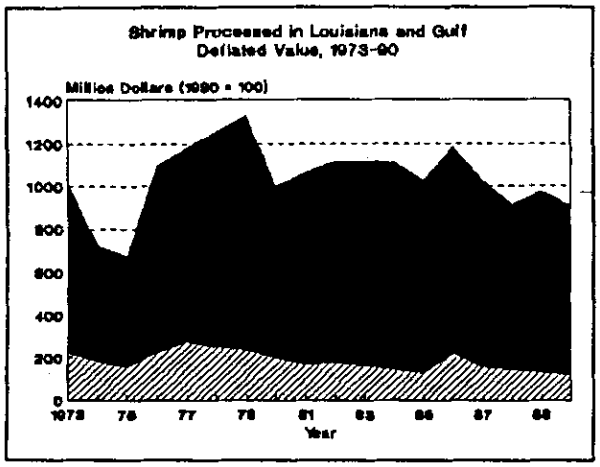


Figure 38

The value of shrimp processing activities in the Gulf Region increased by a factor of more than three during 1973-90, when evaluated in three-year periods. The deflated value, however, peaked at about $1.2 billion dollars in 1976-78 and then fell to $930 million annually in 1988-90, despite an increase in pounds processed.

Overall, Louisiana's share of Gulf Region shrimp processing activities declined during 1973-90, whether measured in pounds or value. In pounds, Louisiana's contribution to Gulf Region processing activities fell from 28% in 1973-75 to 19% in 1988-90. In terms of value, Louisiana's contribution fell from 24% to 14%.

The per establishment deflated value of shrimp processing activities in Louisiana peaked at $4.6 million annually during 1976-78. The deflated value of processing activities per establishment in 1988-90, averaging $3.0 million annually, represented a one-third decline from peak production.

The current value of raw headless shrimp processing activities in Louisiana has remained relatively stable since 1976-78, except during 1985-87 when production activities, at about $86 million annually, were abnormally high in relation to a larger harvest (see Table VII). The deflated value of raw headless shrimp processing activities in the state, however, has declined considerably from the peak years of 1976-78. Much of this decline reflects a sharp fall in the deflated processed per pound price of raw headless shrimp, averaged $6.08 per pound in 1976-78 compared to $4.07 in 1988-90.

The current value of raw headless shrimp processing activities on a per plant basis has averaged two million to three million dollars annually since the 1976-78 period, when evaluated on a three-year basis. After adjusting for inflationary effects, the per plant value of raw headless processing activities has fallen 60% from its peak of $6.2 million in 1976-78 (Table XXVI).

The current value of Louisiana's shrimp peeling activities grew from an average of $7 million annually in 1973-75 to almost $48 million in 1988-90 while the deflated value of these processing activities also expanded from $19 million to $50 million (Table XXVI). The increased value (deflated) was in response to higher production in poundage rather than deflated price as the latter

fell from an average of $3.44 per pound in 1973-75 to only $2.03 per pound in 1988-90 (expressed on a headless, shell-on equivalent weight basis). Peeling activities per plant increased from an annual average of $418 thousand in 1973-75 to $2,371 in 1988-90 when evaluated in current dollars and from $1.1 million to $2.5 million when evaluated on a deflated basis (Table XXVII).

The deflated value of "other" shrimp processing activities fell from a peak of $72 million annually in 1976-78 to less than $13 million in 1988-90, the result of both a decline in pounds processed and a concurrent decline in the deflated price received for the product (Table XXVI). The deflated value of "other" processing activities per plant averaged only $905 thousand annually in 1988-90 compared to $2.8 million in 1973-75 and $3.8 million in 1976-78 (Table XXVII).

Gross Margins and Value Added

Shrimp value extends past the dock. All processing activities add value to the harvested product. Furthermore, the per unit harvest value and per unit processed value can vary considerably depending on the nature and extent of processing activities.

Companies involved in processing Louisiana shrimp often depend on the size count of shrimp harvested. Roberts and Pawlyk, in a 1983 study of Louisiana's shrimp processing industry, documented a large demand of "smaller" shrimp by the industry, primarily for canning purposes. The relevance of Louisiana's canning industry, however, is now much less than during the period of the cited study.

Given the fact that shrimp value extends beyond the dock, Roberts and Keithly (1991) recently completed an analysis of value beyond dockside, the intent of which was to measure the gross margin and value added of alternative processed shrimp products. These products were: peeled-undeveined shrimp, breaded shrimp, and canned shrimp.

The difference between gross margins and value added can be highlighted in a concise manner by defining the two terms (Roberts and Keithly, 1991).

gross margin (markup): The purchase price of a product subtracted from the sale price of the product yields the gross margin. Thus, gross margin is a term associated with two levels in the marketing process. The most used measure is that of difference in purchase price and sale price between producer and the primary wholesaler.

value added: The part of gross margin that indicates payments to labor (wages), management (salaries), fringe benefits, capital (depreciation and profits), and taxes. The contribution an industry makes to an economy is identified by value added. Value added eliminates the double counting in a sales figure. A sales figure includes the products and services purchased from other companies. These purchases of raw material, containers, supplies, fuel and other items must be subtracted from sales to derive a company's (industry's) value added.

Since a company's purchase and sale prices for a product are critical to the gross margin estimate, some product comparability must be identified. For seafood, a

company's purchase price is for raw, unprocessed product. The raw material becomes changed prior to a product being sold by the processor or wholesaler. A fundamental need, therefore, is to have equivalent products upon purchase by the processor (wholesaler) and eventual resale. Differences between prices of equivalent weight can then be estimated and attributed to processing activities. Gross margin (markup) is the monetary differences between equivalent products sold by fishermen and then resold by processors (wholesalers). Value added as a component of gross margin is consequently also dependent on the equivalent product estimation procedure. Roberts and Keithly (1991) considered headless shell-on shrimp to be the raw product.

The importance of differentiating between gross margin (markup) and value added is that the latter is comprised of certain costs that reflect payments to labor, management, and capital and profits. As such, it is a component of gross margin and reflects new value. Other components of gross margin, such as packaging materials simply reflect a transfer of payments from an economic standpoint.

From a survey of Gulf Region processors, Roberts and Keithly (1991) derived value-added estimates for four product types to be: headless, shell-on shrimp, $0.218 to $0.248 per pound; PUD, $0.46 value added per headless pound used to produce PUD shrimp; $0.713 value added per headless pound used to produce canned shrimp; and breaded, $1.65 value added per headless pound used to produce breaded shrimp. Specific components of value added estimates are provided in Table XLI.

The study by Roberts and Keithly (1991) has implications in shrimp management, based on size of shrimp at harvest, to the extent that different shrimp processing activities generally utilize different shrimp sizes. Peeled and cooked shrimp, for instance, require smaller shrimp, on average, than raw headless and breading activities. While the price of these smaller shrimp may be lower at dockside, the value added in processing of these smaller sizes can, at least partially if not totally, compensate for the higher value at dockside associated with larger shrimp.

Marketing Channels

A marketing channel can be defined as the method by which a product moves to its consumer. The only definitive study of marketing channels used by Louisiana shrimp processors and dealers was conducted by Roberts and Pawlyk in 1983. They analyzed marketing channels for four shrimp product forms: heads-on, headless, canned, and "other" shrimp.

Roberts and Pawlyk found that 16% of the shrimp moved by Louisiana's processors and handlers was sold heads-on. Almost all of the heads-on shrimp (95%) was sold in Louisiana and other Gulf states and most of it (93%) was

thought to be further processed. Heads-on shrimp accounted for 50% of all Louisiana shrimp marketed as fresh.

Heads-off shrimp was found to be distributed over a much wider geographic area than the heads-on shrimp. Specifically, over 50% of the headless shrimp was marketed in the Northeast and Midwest. Another 18% was marketed in-state and 15% was marketed in other Gulf states. The authors estimated that 59% of the headless shrimp shipped to other Gulf states received further processing.

Canned shrimp represented 21% of the total amount of shrimp marketed by Louisiana's shrimp processors and handlers in 1983. Much of this was shipped to New Orleans from where it was reshipped to other destinations.

The category of "other" shrimp in the analysis by Roberts and Pawlyk consisted of peeled, dried, and breaded shrimp. Sales in this shrimp category accounted for 17% of all shrimp sales by processors and handlers. Louisiana and the Northeast accounted for 60% of sales while the Southeast represented another 30%.

Changes in Louisiana's shrimp processing activities since 1983, as previously discussed, suggest that the study by Roberts and Pawlyk may not accurately reflect Louisiana's current shrimp marketing situation. Specifically, the large growth in peeling activities in conjunction with the sharp decline in canning activities in the state would suggest that sufficient change in Louisiana's shrimp processing industry has occurred since 1983 to lessen the ability of the 1983 study to accurately depict the current situation.

Shrimp Imports

Supply and Growth

Per capita consumption of shrimp increased by 70% from 1971 to 1991, from 1.4 pounds (product weight) to 2.4 pounds. Most of this growth has occurred since the early 1980s in association with the rapid increase in imports over the past decade. Overall, shrimp consumption represented 16% of total U.S. per capita consumption of commercial fish and shellfish in 1991 (14.9 pounds) compared to only 12% in 1971 (11.5 pounds).

Imports represent a large and growing source of U.S. shrimp supply (i.e., domestic production, imports, and inventories). The growth in imports is illustrated in Figure 39. During 1970-74, imports averaged 243 million pounds annually (headless, shell-on weight equivalent basis). By 1980-84, annual imports had increased to 336 million pounds and equaled 538 million pounds in 1985-89. U.S. shrimp production (warm-water and cold-water shrimp) by comparison, has not grown significantly (Figure 39).

Keithly et. al. (in press) have provided several reasons for the large growth in U.S. imports of shrimp during the 1970s and 1980s. First and foremost, world supply of shrimp has expanded

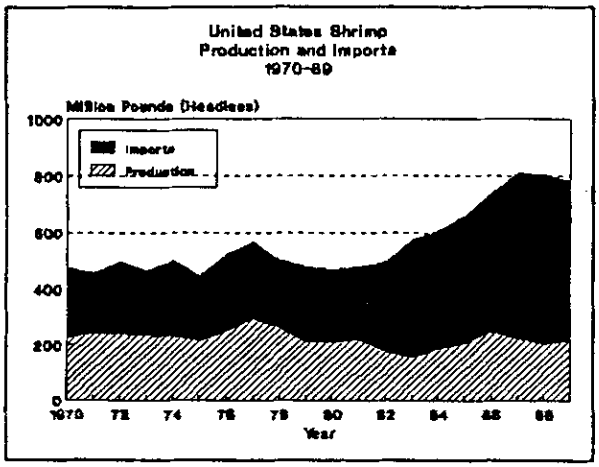


Figure 39

significantly, especially during the 1980s (Figure 40). In 1970, estimated world production was less than 2,000 million pounds (headless). In 1989, estimated world production of shrimp equaled 3,411 million pounds (headless).

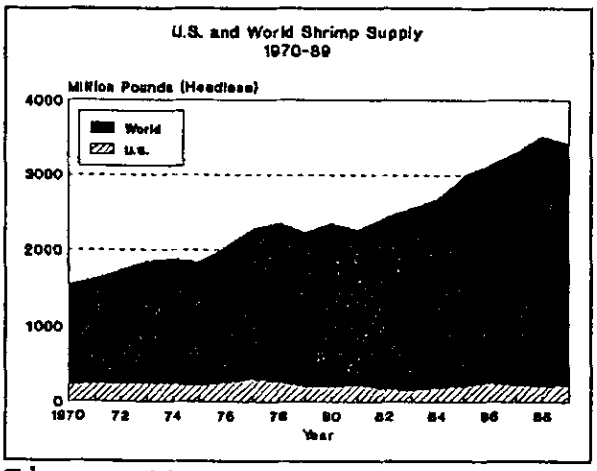


Figure 40

Most of the increase in world supply of shrimp during the early to mid 1970s came from natural shrimp fisheries. Since the mid 1970s, however, most of the increase in world supply has been aquaculture based. Overall, the percentage of world shrimp supplies represented by aquaculture increased from less than 3% of the total in 1975 to an estimated 27% in 1988: an annual growth rate of about 25%. The growth rate from natural shrimp fisheries during the same period was only about 1.3% (Aquatic Farms Ltd, 1989).

A second reason for the increased U.S. imports, according to Keithly et al, reflects the significant increase in U.S. real disposable income during the 1970s and 1980s. This increased income fueled demand for shrimp. Unable to secure additional resources from domestic shrimp suppliers, U.S. shrimp buyers increasingly turned to foreign sources.

Keithly et al. (in press) concluded that each additional ten million pounds of imported shrimp depresses the deflated domestic warm-water shrimp price by about 8.4 cents per headless pound, holding all other factors constant. Since income also increased significantly during the 1970s and 1980s, however, the full impact of increased imports on dockside price was not felt.

Product Form

Shrimp imports enter the United States in a variety of forms including, shell-on (headless), peeled (canned, raw, and other), and breaded. In 1989, shell-on imports of 372.5 million pounds (product weight) equaled 74% of the 503.0 million pounds, product weight, import market. Peeled raw imports of 109.4 million pounds (product weight)

accounted for almost 22% of the import market by product weight. Canned imports of 11.3 million pounds equaled slightly more than two percent of the product weight import market while breaded shrimp imports of less than a million pounds equalled a negligible percentage of the import market.

Sizes of Shrimp Imported

U.S. imports of shrimp arrive in all sizes from the very largest to the very smallest. Tables LXII and LXIII provide annual statistics on U.S. shell-on imports and peeled-raw shrimp imports, respectively, for 1981 through 1988 (more recent data is not available). As indicated, much of the absolute growth in shell-on imports during 1981-88 was established in the "mid-size" count range; reflecting in part increased aquaculture of shrimp in these size classes. The majority of peeled raw imports typically are comprised of smaller, i.e. ≥71 count, shrimp.

Exporting Countries

Latin American countries accounted for about 40% of U.S. shrimp imports by product weight in 1990. Asian countries accounted for almost 60%. Europe, Australia, and Africa also exported small quantities of shrimp to the United Stated in 1990.

China, by far, was the largest exporter of shrimp to the United States in 1990, representing one-quarter of the total by product weight. Ecuador ranked second (17%), followed by Thailand (11%) and Mexico (7%). China, Ecuador, and Thailand are all major farm-raised producers of shrimp.

Chapter 7 - Major Problems of the Fishery

There are three major considerations which affect all options under consideration. One, no major improvement in the fishery is likely unless the amount of fishing effort is significantly reduced. Two, imports and the future business decisions of foreign aquaculturists hold the key to the manner in which the fishery should be managed. Three, degradation of habitat may adversely affect the future fishery no matter what other management measures are put into effect.

Overcapitalization

From an economic perspective, overcapitalization in a fishery refers to a level of effort in excess of that needed to maximize industry profits (or rent). Profits equal total industry revenues minus all industry costs including opportunity costs. Opportunity costs can be defined as the value of capital and labor in best alternative activities. Overcapitalization is a symptom of the open-access nature of fisheries wherein entry into a fishery occurs as long as the industry is generating profits.

The concept of overcapitalization, as it pertains to the shrimp fishery, is further examined in Figure 41. The curve labeled TR represents industry revenues from the sale of shrimp, assuming the price of shrimp to be invariant to the level of catch (this assumption could be relaxed without significantly altering conclusions). It is derived by multiplying the quantity harvested at a given level of effort by the average price of the catch, expressed on a per pound basis. As industry effort initially increases, total revenues increase but at a decreasing rate with each successive unit increase in effort. After some point, additional industry effort

results in only marginal or no further increase in total revenues (approximately E* in Figure 41).

It is generally recognized that the level of effort in Louisiana's shrimp fishery is greater than that needed to maximize total revenue, i.e. beyond E* in Figure 41. While the Louisiana annual shrimp harvest fluctuates widely on an annual basis, this fluctuation is more in response to environmental conditions than to the level of industry effort. To the extent that industry effort is excessive in relation to the minimum amount required to maximize industry revenues, industry effort could be reduced, in concept, without a subsequent reduction in revenue. Since catch by individual fishermen impact the catch per unit effort and the actual catch among other fishermen, this reduction in effort will, in concept, result in higher catches and profits among those fishermen remaining in the shrimp fishery.

While a reduction in industry effort to E* results in a concurrent reduction in overcapitalization, the level of capital is still excessive from an economic perspective. To see why this is so, consider Figure 41 again. The line TR, as noted, represents industry revenues. Industry costs, represented by the line TC, are assumed to increase linearly with effort (this assumption could be relaxed with little change in the final analysis). In an open-access situation, such as the Louisiana shrimp fishery, economic theory suggests that equilibrium occurs where total industry revenues equal industry costs, or at E' in Figure 41 At this point there is no further incentive for individuals to enter the fishery since industry profits have been dissipated. Likewise there is no reason for individual fishermen to exit the fishery since they are covering all of their costs including opportunity costs; i.e., the value investment and labor in the best alternative income generating source.

While equilibrium in the open-access fishery occurs at E', industry profits are maximized at E'' in Figure 41. At this point industry revenues exceed industry costs by the greatest amount.

It is easily seen how overcapitalization is reduced when effort is reduced from E' to E*. In such a situation, total revenues remain constant but less effort is used. The displaced effort in this situation can be used in other aspects of the economy in the production of goods and services, thereby increasing the production of these goods and services without reducing the production of shrimp. Less obvious, however, is the fact that a further reduction in effort to E'' results, from an economic perspective, in an elimination of overcapitalization in the fishery. While a complete discussion of why this is so is beyond the scope of the report (See Anderson, 1986 for complete details) it basically reflects the fact that where industry profits are a maximum, the marginal benefits to society from the last pound of shrimp harvested are equal to

the marginal costs to society of that pound of shrimp. At any level of effort in excess of E'', the capital, labor, and variable inputs used in the production of shrimp could be better employed elsewhere in society.

As noted, the distinguishing element of the Louisiana shrimp fishery (and most U.S. fisheries) that results in overcapitalization and inefficiency is the open-access nature of the fishery and associated externalities that occur. Externalities in the shrimp fishery occur because the production activities by individuals in the fishery impact the production activities of all other fishermen, via the common pool of shrimp. Simply stated, increased catches by one fisherman result in decreased catches among other fishermen. As the number of fishermen increases, this problem is exacerbated. Therefore, as additional fishermen enter the fishery, the catch rates among existing fishermen decline.

The above discussion is based on the economic premise that fishermen determine their activities solely on the basis of economic factors, i.e. their opportunity costs. As long as the given fishery provides a level of income to individual fishermen that is above that which could be generated in the next best source of employment, according to economic theory, they will fish. If the fishery does not provide fishermen an income level that could be earned elsewhere, they leave. While such a theoretical basis helps to explain many of the observations in Louisiana's shrimp fishery, such as the sharp increase in effort in the mid 1980's in association with the reduction in oil and gas employment activities, it is obviously far from complete. As illustrated by Charles (1988), a number of sociological determinants are factored into an individual's decision whether or not to engage in commercial fishing activities. Thus, it is likely that individuals may choose fishing over other occupations even if expected income from fishing is below that which may be earned elsewhere. Too, there may be problems in exiting the fishery, even when income falls below that which can be earned elsewhere due to the inability to recover capital investment costs.

Imports

As noted in the text, imports have increased significantly since the mid 1970's, largely the result of successful shrimp farming activities in the Latin American and Asian regions. The most notable impact of these increased imports is the reduction in the domestic shrimp price. As shown in Table XXXIV, the shrimp dockside prices have declined significantly in each of the Gulf Region states since the early 1980's.

One feature of the increased imports relates to their expected impacts on the domestic shrimp fleet, which can be observed with the aid of

Figure 42. Increased imports, and the resultant decline in the deflated dockside price, is illustrated by a downward shift in the industry total revenue curve form, say, TR to TR to TR_2. As industry revenues decline (expressed in real terms), the equilibrium level of effort also falls, in this case from E′ to E′′. This is consistent with the recent reduction in effort as noted by the reduction in commercial shrimp license sales (Tables I and VI).

A second feature of the increased imports reflects the increased amount of pre-processed products entering the U.S., especially peeled shrimp. In 1980, for instance, peeled imports equaled about 80 million pounds (product weight). In 1990, these imports reached 170 million pounds. As indicated in Table XXVI, Louisiana's shrimp processing industry has, to a large extent, been moving toward a peeled product since the 1970's. The price received by the processors for the peeled product, however, has fallen about 45% since the mid 1970's, when evaluated on a real basis (Table XXVI), which exceeds the decline in price of any other processed products. If foreign suppliers continue to increase value-added activities, as many industry leaders anticipate, Louisiana's shrimp processing sector could be further depressed.

A third feature of the changing import market that needs to be assessed is the changing size structure of the imported product. When farm-raised shrimp products were first exported to the United States on a large scale, primarily from Ecuador, they tended to fall in the mid-size ranges. However, farm-raised shrimp products now cover a much wider range of sizes with China producing some of the larger shrimp and Ecuador producing some of the smaller shrimp. Determining future sizes of shrimp imports is near impossible but one generalization can be made. The cost of post-larvae is a relatively large component of the total shrimp farming cost. This suggests that shrimp farmers will not find it profitable to harvest shrimp at a small size (> 80 count to the pound). In developing a management strategy for the Louisiana shrimp fishery, it is important to realize that producers of farm-raised shrimp can alter their optimal mix of size categories, which would depend on input costs relative to output prices of different sized shrimp, much easier than could be accomplished in a natural setting where capital is relatively inflexible in the short run.

Bycatch

Shrimp trawls came into use in Louisiana in the early twentieth century. As early as 1936, discussions of the "shrimp trawl--fish" problem were taking place. Lindner (1936) asked the question: "Is the shrimp trawl causing serious damage to the sport and commercial fishes of the south. Lindner listed both possible benefits and possible harm from

shrimp trawling:

Possible benefits included:

1. Increase in shrimp supply by reducing numbers of predators. Predators could be reduced both from direct capture by the trawl and from reduction in food supply from capture of large amount of shrimp.
2. Increase in growth rate and fatness of fishes by thinning out young. If the number of young fish were so great that food supply was a limiting factor, a reduction in the number of fish would increase the condition factor of those that survived.
3. Increase in numbers and growth rates of species of fishes by supplying trash fishes as easily available food. Trash fishes were those which have no direct economic value.
4. Providing food by plowing or stirring up bottom. It was recognized that tides and currents in shallow waters probably had more effect than trawls.

Possible harm included:

1. Depletion of the supply of sport and commercial fishes, by direct capture in the trawl or by reduction of food supply. Assessing the abundance and fluctuations of the fish was recognized as a major problem. The possibility that a species of fish could be depleted by trawling for shrimp even though there was no direct fishery on that species was recognized.
2. Increase in numbers of predators by supplying easily available food.
3. Encourage sharks to approach bathing beaches.
4. Drive fishes away from an area. The effects of trawling on the behavior of fish was considered to be temporary.
5. Destroy spawning grounds.

Lindner (1936) recognized that increase in fishing effort by both commercial and recreational fishermen would complicate any attempts to assess the effects of trawling on marine populations. In addition, even in 1936, oyster reefs were being depleted, having an unknown effect on the populations of fishes.

Lindner (1936) concluded that the effects of trawling would resolve itself into an economic, rather than biological, problem, with the efficiency of the trawl in catching shrimp overcoming any possible but uncertain detrimental effects on fish populations (Lindner 1936).

Gunther (1936) that same year also discussed the destruction of marine fish by shrimp trawlers in Louisiana. Discard data taken by Gunther in 1932-33 is compared to the Department's 1989 discard study in Table XL. Gunther's data is the results of 313 hours of trawling by the research boat "Black Mallard"; the Department's data is the result of 324 hours of trawling by randomly interviewed commercial vessels. The catch per trawl hour is listed for those species cataloged by Gunther, sorted by the catch rate found by Gunther. Although there are questions of differences in procedure and of comparability of data sets taken over 50 years apart, Table XL does indicate differences in abundance of many species.

Total number of the

species listed by Gunther was 403 individuals/hour; the Department found 457 individuals/hour. In the early 30's the catch was dominated by Atlantic croaker, which constituted 51% of the total number; in the late 80's croaker catch was only 3.5% of the total number. In the 30's croaker and Star drum were the two dominant species, constituting 59% of the total number. In the late 80's, that combination contributed only 3.6% of the total. Bay anchovy and Gulf menhaden were the two top species in the 80's, accounting for 18% of the total number; in the 30's they accounted for 11% of the total. The catch/hour of Atlantic croaker in the 80's was 8% of that found by Gunther; the abundance of Star drum was 1%. Five of the top 6 species of the 30's (Atlantic croaker, Bay anchovy, Sand seatrout, Seacatfish, and Gulf menhaden) were in the top 6 of the 80's. The drastic reduction of Star drum has made it a minor component of modern day catches. The top 6 species of the 30's comprised 80% of the total number. The top 6 species of the 80's account for only 28% of the catch. This loss of dominance is primarily due to the reduction in croaker catch. Of the fish species of interest to harvesters, Sheepshead, Spanish mackerel, and Atlantic spadefish were relatively more abundant in the late 80's; Sand seatrout, crevalle jack, southern flounder, southern kingfish, spotted seatrout, Florida pompano, and silver seatrout were relatively less abundant in the trawl catches.

In 1936 Gunther recommended that shrimpers be persuaded or required to quickly sort fish from trawls and throw them overboard in the hope of reducing their mortality; he believed that trawling was adversely affecting the fish populations. Twenty years later he again addressed the problem (Gunther,1956). He noted that the total population of fishes was as numerous as it had ever been, in spite of increased shrimp trawling effort in the previous 25 years. With regard to recent developments of a trawl fishery for finfish he expressed the opinion "without equivocation that there is not and never will be any direct effect of the trash fish industry upon commercial and sport fishes of the Gulf of Mexico, so long as the method of harvesting is confined to trawlers".

TEDs

Commercial shrimpers view Turtle Excluder Devices as having a major impact on their method of operations. In spite of the fact that NMFS has claimed that recent versions of the TED have little impact on shrimp catch, shrimpers disagree. TEDS are mandated by federal law; Louisiana Law specifies that the state will not enforce those federal regulations pertaining to TEDS.

Habitat Loss

Louisiana is rapidly losing its wetlands; wetlands are the basis for shrimp

production. Recent studies by NMFS suggest that the 1960 to present increase catch of shrimp off Louisiana may be driven by a temporary increase in nursery area associated with marsh subsidence. If this is actually occurring, when the rate of stimulation declines, the fishery could go into a state of collapse.

Habitat loss is the single most important threat to the fishery from a biological standpoint. Brown and white shrimp production is closely tied to suitable estuarine habitat. While the early process of marsh loss may stimulate a short term increase in production, once a critical level is passed production will decline.

More drastic and dramatic losses in shrimp production and in the ability of the population to maintain itself are associated with privatization of public water bottoms and in denying juvenile shrimp access to the shallow bays and estuaries and flooded marsh surfaces, as through bulkheading weir construction.

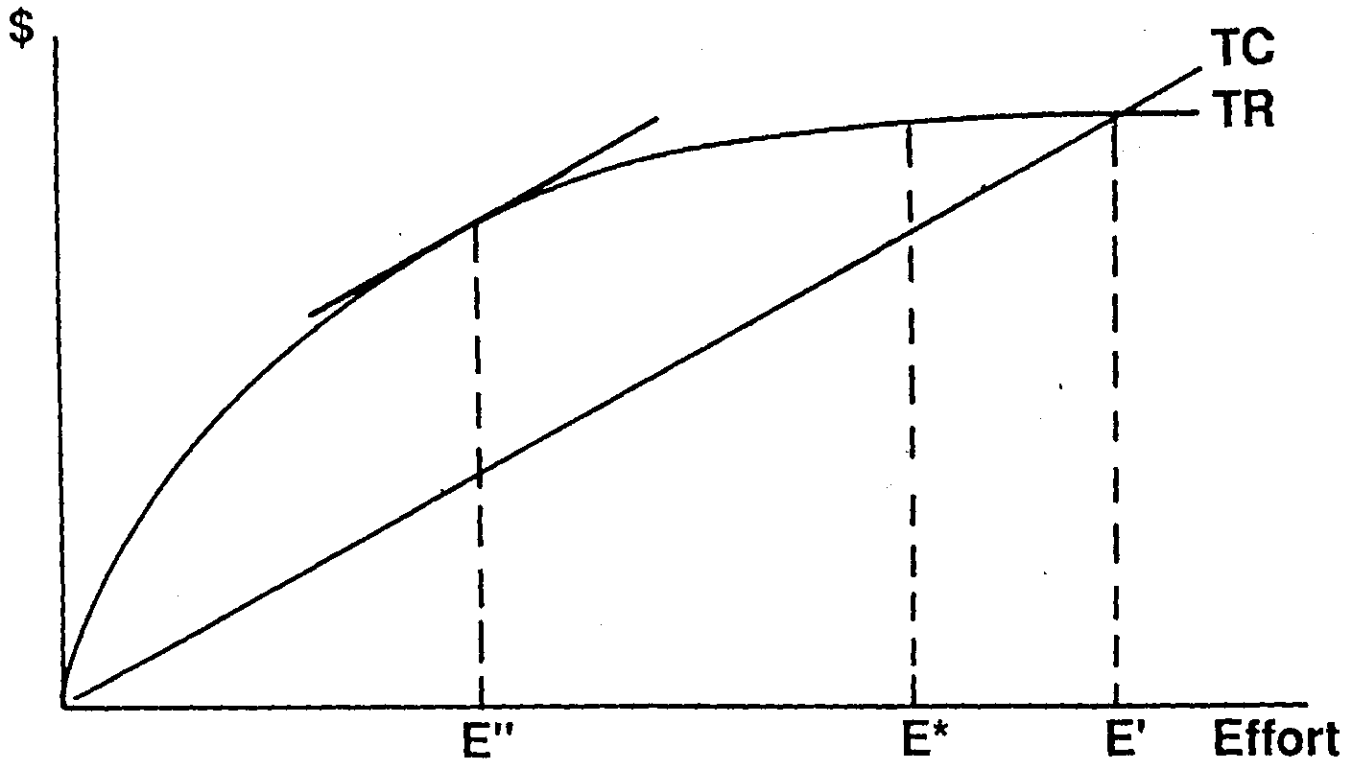


Figure 41. Expected Economic Relationship Between Industry Effort and Revenues in Louisiana's Shrimp Fishery

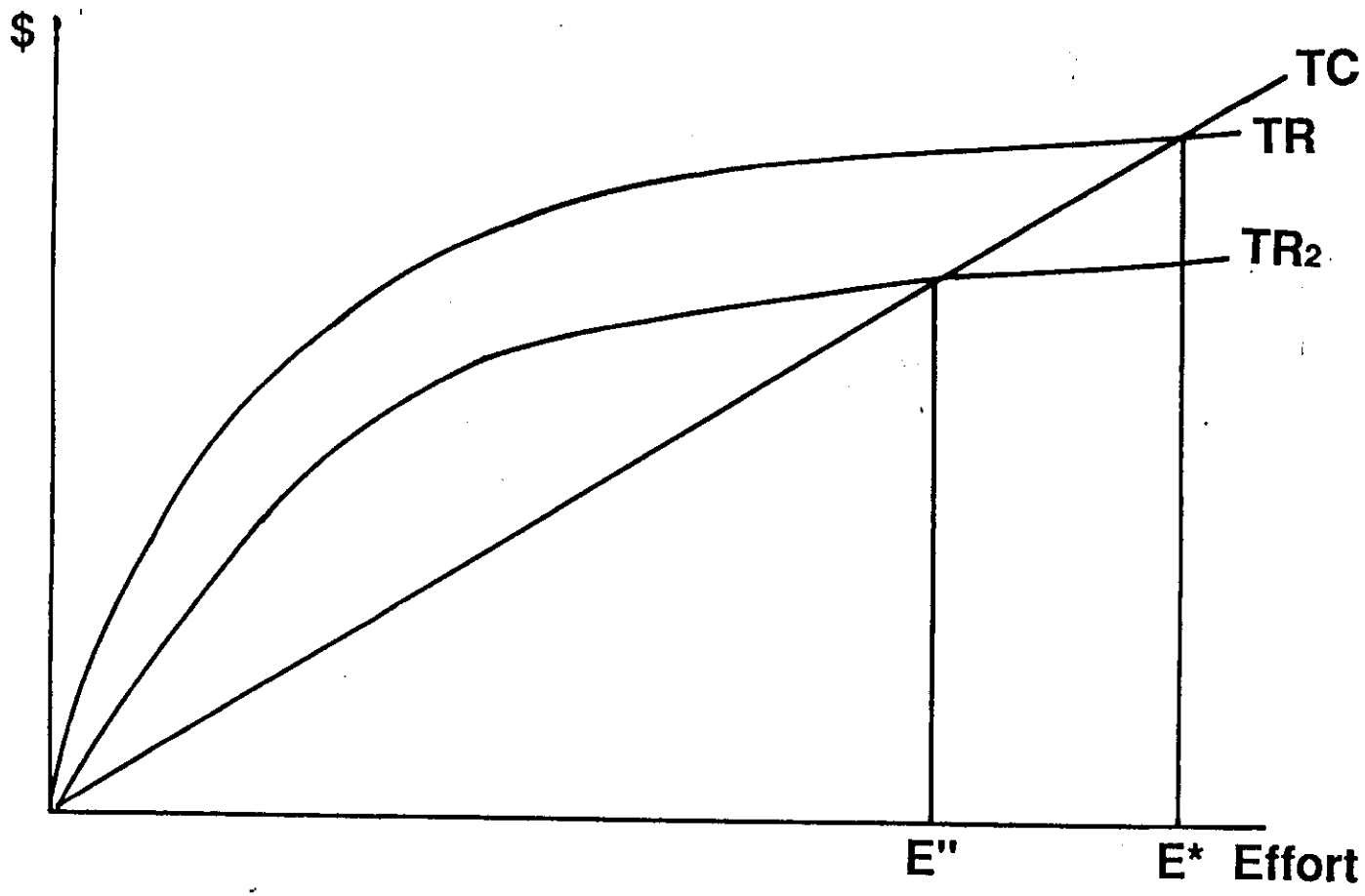


Figure 42 Expected Relationship Between Increased Imports and Effort in Louisiana's Shrimp Fishery

Chapter 8 - Current Management Policy

Legislative Intent

The Louisiana Legislature, the policy making branch of state government, has passed several acts which provide guidance in developing goals and management objectives for the shrimp management plan. Some of these acts directly address the shrimp fishery; others address related fisheries or renewable resources but can be adapted to the management of the shrimp resource.

Legislative policy concerning the seafood industries has been stated as (56:571(A)):

> Recognizing the value of the seafood industry to the economy of the state of Louisiana, recognizing that the seafood industry employs hundreds of Louisiana citizens, thereby decreasing unemployment and the burden unemployment places on the state fisc, and further recognizing that the commercial fishing industry is in danger of collapsing as an industry due to escalating fuel prices, governmental regulations which have increased competition for limited state resources from non-Louisiana residents, and from costs of labor, fishing gear, and supplies, it is the policy and purpose of this Subpart to provide every method of encouragement and assistance to the commercial fishermen of the state of Louisiana, to protect a culture and heritage that is unique to Louisiana, to prevent unemployment of Louisiana citizens, to assure adequate food for Louisiana citizens, and to provide for economic stability in those areas of Louisiana so dependent on the seafood industry. To that end, the state shall foster and encourage its seafood industries.

In developing a policy for a mariculture industry in the coastal zone, the legislature has stated that it is the policy and purpose of the legislature "... to protect the culture and heritage that is unique to Louisiana, to prevent unemployment of Louisiana citizens, to assure adequate food for Louisiana, and to provide for economic stability for those areas of Louisiana so dependent upon the seafood industry." (56:579.1(A))

In 1991, the Legislature passed the Saltwater Fishery Conservation and Management Act (Act) (56:638.2). Although specifically devised for the management of the saltwater finfish resources, the Act provides legislative intent, findings, and policies which

are directly applicable to the management of Louisiana's shrimp resources. The Legislature recognized that:

- the value of the fishery resources include but are not limited to providing food, employment opportunities, social benefits, economic benefits, and recreational opportunities
- the fishery resources are renewable; with proper management they will provide benefits to the state indefinitely
- increased fishing pressure and/or other factors may cause the fishery stocks to become overfished
- a management program is necessary to prevent overfishing and realize the full potential of the resource

The Legislative policy stated in the Act (56:638.4) for management of Louisiana's marine finfish resources is:

> Stewardship of the state's saltwater finfish resources shall have as its utmost concern the continued health and abundance of the resource and its environs, shall provide for optimum sustained benefits to the state, shall be responsive to the needs of interested and affected citizens, shall ensure the proper and fair utilization of these resources for the citizens of the state in present and future generations, shall preserve the state's exclusive right to manage the fisheries within or beyond its jurisdiction, and shall be based on the best scientific information available. In addition, such stewardship of the state's shrimp resources shall draw upon federal, state, and academic capabilities and promote efficiency in carrying out research, administration, management, and enforcement.

The Legislature adopted standards for the harvesting, conservation, and management of the marine finfish resource (56:638.5); these standards (which essentially emulate those of the federal Magnuson Fishery Conservation Management Act) may be summarized as:

1. Conservation and management measures shall prevent overfishing;
2. Conservation and management measures shall be based upon the best scientific, economic, biological, and sociological information available;
3. To the extent possible, an individual stock or unit of fish shall be managed as a unit throughout its range within the state's jurisdictional authority;
4. If it becomes necessary to allocate or assign fishing privileges among various fishermen, such allocations to the extent practicable shall be:

a) Fair and equitable to all such fishermen;
b) Reasonably calculated to promote conservation;
c) Carried out in such a manner that no particular individual, corporation, or other legal entity acquires an

excessive share of such privileges;

d) In the best interest of the citizens of Louisiana.

5. No conservation or management measure shall have as its sole purpose economic allocation of the resource.

6. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

7. Conservation and management measures may take into account and allow for variations among, and contingencies in, fisheries resources and catches.

Other Legislative policy important to the management of the shrimp resources includes the "Right to Fish Law" (56:640.1). This law states that legal methods to harvest any species of fish (including shrimp) should not create a severe economic and personal hardship on the fisherman using said method; existing legal methods of harvesting may be eliminated only if it is found that they are damaging the fish resource (56:640.3). No one is allowed to disturb or interfere with a fisherman engaged in the lawful harvest of the resource (56:648.1).

In creation of the Louisiana Seafood Promotion and Marketing Board, the Legislature recognized impediments to the economic well-being of Louisiana's commercial fishery industry because of the lack of a well-coordinated marketing effort. It created the board to promote the "catching, harvesting, processing or packaging of seafood in Louisiana" (56:578.1). The Legislature has also determined (56:326.4(A)) that " Louisiana has a national reputation for serving unique and high quality seafood dishes, that the availability of fresh popular fish to serve in Louisiana restaurants is important to the vitality of our culture and economy. Further, the legislature finds that it is in the best interest of the state that the Louisiana Wildlife and Fisheries Commission be authorized to set seasons and quotas for fishing in such a manner as to maximize the availability of popular fish for serving in Louisiana restaurants."

Current Objectives

A synthesis of the Legislature's policies concerning Louisiana's saltwater fishery resources leads to a construction of the following current objectives for the Shrimp Management Program:

1. Perpetuate the renewable shrimp stocks;
2. Enhance the economic benefits provided by the resource to Louisiana;
3. Conserve the cultural heritage of the fishery;
4. Conform to the spirit and standards of the federal Magnuson Fishery Conservation Management Act.
5. Increase employment in the shrimp industry
6. Provide for the economic stability of the fishery

7. Provide for a constant supply of shrimp to Louisiana restaurants.

Chapter 9 - Management Measures Considered

Conservation and Management Options

Traditional Open Access Methods

Louisiana's current shrimp management structure is an "open access" system. Any individual who purchases the required licenses is allowed to participate in the industry.

While this situation is ideal for the individual contemplating entering the fishery, it is less than perfect for the industry. A fisherman will tend to enter the fishery whenever his net revenues exceed his opportunity costs, i.e. when his profit equal or exceed the income he could generate in some other activity. His entry into the fishery generates an "external cost" (i.e. indirect cost) to the fishery in that his extra fishing effort results in a reduced catch/effort for everyone in the fishery. However as the new participant sustains only a small proportion of this external cost, it has no bearing on his decision to enter the fishery. This is only one of several types of external costs which adversely impact an open access fishery. Another is the common property nature of the resource. As no individual fisherman owns or controls the resource, it is in his own best interest to harvest as much of the resource as he can in the present; it does him no good to postpone harvest to a later date because someone else may then catch the fish. (Waters, 1992).

The current management system does have its benefits. First, it is flexible; shrimpers may target all of the economically useful sizes of shrimp. Second, change within the industry is the result of market forces rather than regulation.

There are innumerable ways in which the industry could be consciously restructured, if desired. Before costs and benefits of major change can be determined, the nature of an alternative management scheme must be determined. The current regulation on count sizes at opening, i.e., 100 ct, was likely instituted for economic purposes. Therefore, LWFC can be said to open and close based on economic rationale.

Gear and Vessel Restrictions

The concept that trawls of different mesh sizes should retain shrimp of different sizes is intuitively pleasing. However, there does not appear to be a body of published literature which would allow a quantitative analysis of the relationship for shrimp in Louisiana waters.

Patrice Phares of NMFS examined the available data off the Texas coast and failed to find a consistent pattern. She concluded that this lack of a consistent pattern was due to variation in the manner in which the trawls were hung as well as variation in the bottom types and water conditions encountered (Phares, personal communication 1978).

Seasons

As discussed in the Yield Per Recruit and Biological Sections variable opening dates are biologically justified in terms of enhancing yield. Growth of brown and white shrimp is highly dependent on water temperature and size. In addition, recruitment of the major wave of postlarval brown shrimp to the Louisiana estuaries in March-April is not uniform; recruitment normally occurs first in the central part of the state, followed normally two weeks later in the eastern and western estuaries.

The yield analysis demonstrates that the policy of variable openings has benefitted the fishery in terms of yield. Additional seasonal delays are biologically justified from a yield standpoint as discussed in the Yield Per Recruit Section. If properly timed, variable opening date can result in increased value of the fishery at dockside. They also provide maximum management flexibility based on scientific analysis. If properly timed, zone openings can increase overall dockside value of the fishery. Variable openings do create the potential for crowding, but studies cited previously indicate that mobility is relatively low. However, there are little relative benefits in opening the inshore fishery in a five day window about the moon; this procedure would regulate inefficiencies while producing no lasting economic benefit.

Fixed season openings have the benefit of allowing both harvesters and dealers/processors to plan in advance. The potential that some people may get caught unprepared by an early opening date is eliminated. Part-time shrimpers are able to plan vacation/leave accordingly.

Size Limits

Brown and white shrimp are extensively growth overfished. The annual harvest of brown shrimp begins when half of the population is expected to be less than 161 tails to the pound. Any white shrimp greater than 161 tails to the pound may be retained.

Increases in the size at which both brown and white shrimp are harvested is biologically justified in terms of yield, depending on the rate of natural mortality. The yield per recruit plots in

Figures 23 and 24 give general guidance. In addition, the text of the Yield Per Recruit Section gives specific suggestions.

The potential benefits of larger initial size comes primarily from a potential increased dockside value. If the initial size were too large, however, much of the increased value may accrue to out-of-state fleets in federal waters. Adverse costs of larger initial size include the possibility that such an action would exclude portions of the fleet, a reduction in the total value of fishing, and a disruption in processing activities. Additional information is required on specific targeted size counts before complete economic assessment can be made. Even then, data limitations are likely to preclude detailed economic analysis.

Moving away from minimum count restrictions by targeting minimum size of capture through regulation of mesh size would provide minimal economic benefits unless culling is a serious problem in inshore waters. An indirect benefit, however, may be a reduction in bycatch. There is a potential of increased enforcement costs, however, from such policy and any additional costs would need to be weighed against potential benefits.

Area Closures, including Sanctuaries

Gaidry and White (1973) classified Louisiana's estuaries into four divisions: primary nursery areas, inshore deeper lakes (staging areas), near offshore, and offshore. They noted that although fishing pressure was exerted on shrimp in all four of those divisions, shrimp (especially brown shrimp) rarely reached commercial size in the primary nursery areas. They indicated that often 80% of the catch in the nursery areas were discarded. Even at the Rockefeller Refuge, which was a shrimp sanctuary without fishing pressure, brown shrimp emigrated from the nursery area before reaching commercial size.

"The most significant management measure that could be implemented in response to the penaeid shrimp study would be to delineate the nursery and the staging areas within each study area. The nursery areas should be closed to all trawling activities on a permanent basis. The employment of this measure would eliminate the wasteful destruction of the unusable small shrimp, and at the same time perpetuate a sustained yield of larger, more desirable shrimp in the larger embayments (staging areas) along the coast...In almost every case, studies have shown that the smaller, shallow nursery areas do not produce a commercial size shrimp...The larger bays and lakes found along the entire Louisiana coast comprising the staging areas should be designated. This study and earlier studies have shown these staging areas to be the recipient for the larger transient penaeid shrimp utilizing these areas prior to their offshore migrations. Only a small percentage of the population utilizing the

staging areas have been found to be undersized." (Gaidry and White, 1973)

White and Boudreaux (1977) elaborated on the concept of sanctuaries. With the transcendence of trawling over seining as the major method of harvesting shrimp, "de facto" sanctuaries had come into being. Harvesting vessels had deep drafts and were capable of operating only in the deeper bays and lakes along the coast, i.e. the staging grounds; they could not pursue shrimp into the shallow nursing areas. However with the advent of outboard motors and shallow draft boats, it became possible to harvest shrimp wherever they were to be found in the inner marshes. They confirmed the findings of Gaidry and White (1977), i.e. the nursery grounds are primarily inhabited by shrimp too small to be of commercial size.

White and Boudreaux (1977) recommended that the inner marshes and shallow lakes and bays be designated sanctuaries for shrimp. Their recommendations were based on size and density of catch from the recommended areas. Other areas were included in which samples were not taken, however which showed certain characteristics of depth, environment, and hydrology as to indicate any shrimp present would not usually be of commercial size.

In 1973, a special Louisiana Legislative study committee held coastwide hearings addressing the creation of shrimp sanctuaries. The concept received favorable comments west of the Mississippi River. However, shrimpers east of the River were so adamantly opposed to the concept that the proposal to create such sanctuaries was dropped and has not since been seriously considered.

An implementation of the sanctuary concept developed and published by Gaidry and White (1973) and White and Boudreaux (1977) is biologically justified from a yield per recruit consideration. Extensive research by LDWF has shown that brown shrimp less than 100 count and white shrimp less than 68 count normally inhabit very shallow waters. The sanctuary concept, as published in White and Boudreaux (1977), would close these waters to shrimping, and leave the major bays open. Such a closure would increase yield in the fishery by decreasing the discard of undersized shrimp and by decreasing growth over fishing. To the extent that it protects other species from harvest, it is also biologically justified.

Benefits of a sanctuary system would include an increase in shrimp size and corresponding value at dockside; there would also be potential short-term benefits for larger boats. On the other hand, there would be some economic costs. Small boats might be displaced. If size of shrimp increased significantly as a result of sanctuaries, there may be a reduction of "small" shrimp available for peeling activities. This would reduce the value-added component of processing sector. For the sanctuary concept to work properly, enforcement would have to be adequate. This

suggests that associated costs would rise. Finally, prohibiting shrimping in certain areas will result in additional economic inefficiencies.

Limiting Effort and/or Entry

A reduction in effective effort is the most biologically justifiable option for the fishery for at least four reasons. First, as discussed in the Yield Per Recruit Section, the current levels of effort are not required to obtain the current level of harvest. Dramatic to slight reductions in effort will obtain the same or higher levels of harvest, depending on the level of natural mortality. Second, reductions in effort will enhance the likelihood that individual shrimp will reach sexual maturity and spawn. This will increase the probability of continued good recruitment of larvae and the maintenance of the population at a high level of abundance. Third, reductions in effort will decrease the bycatch of other species, thus increasing their natural abundance and spawning potential. Fourth, if effort is not limited the Biological Analysis indicates that any increases in effort will result in slight decreases in yield, given the current sizes at entry.

Louisiana's shrimp fishery is multi-jurisdictional in nature. Attempts to limit entry in state waters without cooperation in federal waters may result in excessive crowding in federal waters. Potential benefits from limited entry would be greatly enhanced if action is taken simultaneously in all waters. Significant economic and social costs related to limited entry include potential loss of processing capabilities and lack of job opportunities. If properly constructed, a limited entry program, can provide benefits in the form of higher income among fishermen and increased economic efficiency.

Waters (1992) discussed limited entry as a method of fishery management. He states that economists are interested in the long-term achievement of fishery management goals in an economically efficient manner. "Economic efficiency is loosely defined here as society's ability to maximize the combined value of commercial, recreational, and aesthetic products and services that can be obtained for a given level of cost, or the achievement of a given level of products and services at a minimum cost. Economists advocate limited entry as a method of fishery management because economic efficiency is not likely to be achieved in an open-access fishery." "Limited entry attempts to overcome the problem of external costs and its built-in incentives to overfish through the creation and enforcement of property rights where they have not evolved naturally. More correctly, limited-entry systems of management introduce elements of property rights into a fishery through the issuance of what may be called fishing rights, fishing privileges, or the right of access to the fishery. Limited entry does not assign ownership of the ocean or the fish in

it." (Waters, 1992)

License Limitations

As noted by the title, effort can be controlled through limiting licenses and, hence, the right to fish. Limiting license can vary from relatively simple forms, such as a moratorium on the issuance of new licenses, to more complicated systems, such as minimum income criteria required to obtain a license. Waters (1992) provides a detailed discussion of economic and other considerations related to license limitation schemes.

Success of Limited Entry Programs

Success/failings of entry restrictions programs throughout the world have recently been analyzed by Townsend (1990). He identified certain characteristics of different programs that have helped to establish their success. Some of these characteristics are presented below.

1. The restrictiveness of a program is correlated to its economic success. As a whole, those entry restriction programs that have been most restrictive have also been most successful. Less restrictive programs, such as moratorium on entry that included a phased reduction in effort, have been only marginally successful. The least restrictive programs, such as a moratoria that did not include a phased reduction in effort, have shown little economic success. Those programs that have been most restrictive, however, are potentially very expensive in terms of enforcement expenditures and /or high compliance costs by the fishermen.
2. In general, there is an inverse relationship between the complexity of the fishery and the success of management.
3. The success of any limited entry plan will be affected by the social and political environment. As noted by Townsend (p. 372) "when management must contend with basically antagonistic social attitudes,..., management is even more difficult."
4. There is little evidence that weak limited entry programs evolve into strong successful plans.

These generalizations provide at least a basic guidance for the Louisiana shrimp industry if and when it decides to evaluate a limited entry scenario for the fishery. It is an extremely complex fishery with full- and part-time fishermen, inshore and offshore waters with a species that grows in size and value as it moves offshore, different gear types, and state and federal jurisdiction. This suggests difficulties in establishing a limited entry strategy.

Ownership Programs

Ownership programs have long been advocated by economists as a means of increasing economic efficiency. Economic efficiency can most easily be enhanced by providing ownership rights to the resource. For Louisiana's shrimp fishery, ownership to the resource can be conveyed by two means: (1) catch rights, and (2) mariculture.

Catch Rights

As opposed to license limitation schemes, catch rights represent a system by which fishermen are given a generally transferrable certificate that confers to them the right to catch and sell some small proportion of the total allowable catch. The fishermen, in such an example, are given ownership rights to the resource, thereby mitigating common property problems. This total catch is determined by the agency whose purview it is to manage the fishery and can be changed on an annual basis reflecting changes in the stock size. Such a policy would require very strict enforcement for it to be successful.

Mariculture

Economic inefficiencies in the shrimp fishery result from treating it as a common, rather than private, property. A solution to this problem, therefore, is to convey property rights to the resource. One method of conveying these property rights is through mariculture permitting along the coast. Under such an ownership scenario, the owner is encouraged to invest in the shrimp resource and "undertake measures that will increase the productivity (yield) in the fishery" (Tietenberg, 1992). These measures include the maintenance/ and improvements of the wetlands so critical in the shrimp's life cycle.

Legal Considerations Affecting Management Options

What follows is a legal review of possible shrimp management options discussed in this Shrimp Plan. These options have been reviewed in light of current Louisiana statutes, the Louisiana Constitution of 1974, the federal Magnuson Fishery Conservation and Management Act, and the United States Constitution. A particular "backdrop" against which these options have been reviewed is the public trust management responsibility of the Department, the Commission, and the Legislature pursuant to Act IX, Sec. 1 of the Louisiana Constitution, for managing the Louisiana shrimp fishery resources "consistent with the health, safety, and welfare of the people."

Sanctuaries

The establishment of sanctuary areas offlimits to

shrimping in Louisiana is a legally viable option. The Legislature established a sanctuary in Lake Catherine and Lake Pontchartrain in Act 476 of 1954.

The most difficult aspect of establishing the coastwide sanctuary proposed by Gaidry and White (1973) and White and Boudreaux (1977) is establishing a legally definitive boundary. It would legally be more appropriate for the Legislature to give the Commission and Department specific authority to establish sanctuaries, including the authority to specifically delineate sanctuary boundary lines, subject to legislative oversight under the Louisiana Administrative Procedure Act, La.R.S. 49:950, et seq. (LAPA).

This approach would get away from tying up time in the Legislature each year to amend sanctuary lines, as has been the case with the inside-outside shrimp line and allow necessary boundary adjustments easily. See Chronological History of Shrimp Legislation in Louisiana.

Regulations on Mesh Size

The mesh size for shrimp nets (seines, trawls, etc.) has historically been established by legislation rather than regulation. It can be argued that this would be better handled by authorizing the Commission to set and adjust mesh sizes, as needed, subject to legislative oversight under LAPA.

Variable Shrimp Opening Dates

Act 893 of 1988 gave the Commission nearly complete authority to set open and closed shrimp seasons, including authority to set special seasons. This action was based on a recommendation included in the 1984 Report of the-then legislatively-created Task Force on Shrimp Management. Consequently, this option can be achieved by Commission regulation, subject to legislative oversight under the LAPA.

Limited Effort

With respect to the several proposed options that would result in some reduced, or limited fishing effort in the shrimp fishery (i.e., a "365-day" season; a five-day "window" about the moon; and a specific limited/reduced effort program, like license limitation or individual transferable quotas), the legal issues arise primarily under the U.S. and Louisiana constitutions. Initially, however, it is clear that the legal issues are of such complexity, that any such program by the state of Louisiana should be accomplished by detailed, well-crafted legislation. There are certain aspects of administering such a program that are more properly the purview of the Department and the Commission, by regulation, but the complexity of such a program is so great that is more properly created by legislation.

The major difficulty in establishing a limited/reduced effort program in the Louisiana shrimp fishery are the

constitutional provisions for: substantive due process of the law (U.S. and Louisiana constitutions), protection of individual property rights (both constitutions); regulation of interstate commerce; equal protection under the law; and the protection of the privileges and immunities of citizens from other states. The relationship of these provisions to a limited entry/effort program for fisheries will be discussed, each in turn.

The provision for substantive due process of the law is found in Amendments 5 and 14 of the U.S. Constitution and Article I, Sec. 2 of the 1974 Louisiana Constitution. The due process clause provides that no one is to be deprived of life, liberty, or property without due process of the law. Substantive due process has been described thusly:

> "The guarantee of due process . . . demands only that the law not be unreasonable, arbitrary, or capricious, and that the means selected shall have a real and substantive relation to the object to be obtained."
>
> Nebbia v. New York, 291 U.S. 502 at 510 (1934).

Even though the freedom of individuals to earn their livelihood by any lawful calling, e.g. commercial shrimping has been recognized by the courts, they have held that such freedom is not absolute and that even a legitimate occupation can be restricted in the public interest. Since 1937, the Supreme Court has tended to uphold almost any such legislation which serves some overriding public interest. In short, substantive due process holds all legislation to a general standard of "reasonableness." As interpreted through court decisions, 2 tests have been established to determine whether a piece of state legislation, or a regulation, has met due process requirements: (1) is the end sought by a particular law a legitimate goal for the exercise of governmental power? and (2) are the means used to reach this goal reasonably adapted to achieve it? Consequently, a limited/reduced effort scheme in Louisiana must be able to answer these 2 questions in the affirmative.

Article V of the U.S. Constitution and Article I, Sec. 4 of the 1974 Louisiana Constitution provide that private property may not be "taken" for public use without payment of just compensation. This is referred as the "takings clause". Article I, Sec. 4 also provides that private property may not be "damaged" for public use without just compensation. A "takings clause" claim against a Louisiana limited/reduced effort program is most likely to be based on a claim of a "taking" of a shrimper's "property" without payment of just compensation.

The legislature, the Department, and the Commission are the public trustees for the shrimp resources owned by the people of Louisiana. A licensed shrimper in Louisiana holds a permit to fish this common property resource. To the extent that a limited/reduced effort plan for the shrimp fishery in Louisiana would prohibit a shrimper from

further shrimping, restrict the amount of effort a shrimper can exert, or assign an individual "take", the "takings" issue must be considered in developing the limited/reduced effort scheme.

Since a shrimper's license is a permit to fish for a resource owned in common by the citizens of a state, it is not clear whether a license limitation scheme would constitute a "taking" of private "property", i.e., in this instance, a license. A "grandfather clause" including current licensees could alleviate this problem, if a license to shrimp is determined to be "property". To the extent that a limited/reduced effort scheme would render a shrimper's equipment and vessel useless to him, this also might be considered a "taking". These issues will require careful drafting of the limited/reduced effort scheme. In addition, the matter of whether such scheme constitutes unlawful "damage" to private property under Article I Sec. 4 of the Louisiana Constitution must be taken into consideration.

In order for a Louisiana limited/reduced effort to meet the U.S. constitutional reservation of regulation of interstate commerce to Congress, the scheme adopted by Louisiana must be found not to be a burden on interstate commerce. This requirement will require particular attention to provisions of a limited/reduced effort scheme that reduces-or eliminates-the effort of out of state shrimpers. The tests for determining a "commerce clause" violation is whether the proposed scheme constitutes a "direct or actual burden" on interstate commerce as opposed to only an "indirect burden". If the local benefits of the scheme are substantial, and it will only constitute an "indirect burden", then its constitutionality can be upheld.

The "equal protection" provisions of the 14th Amendment to the U.S. Constitution states that "No state ... shall deny the 'equal protection' of the laws". (This "equal protection" provision has been held to apply to the federal government through the due process clause of the 5th Amendment.) This "equal protection clause" has been held to apply to any "classification" scheme, i.e., laws or regulations, which create benefits for some members of society while denying those benefits to others.

Since a limited/reduced effort scheme likely creates such a division, the scheme would need to meet two "equal protection" tests: (1) is there a legitimate goal involved in the exercise of legislative power? and (2) is there a reasonable relationship between the classification made and the purposes of the statute. The freedom guaranteed by the "due process" clause is freedom from arbitrary and capricious actions by government. A limited/reduced effort scheme in Louisiana would have to be drafted in such a way as to meet these 2 tests.

The final constitutional test that a Louisiana scheme

wold have to meet is the privileges and immunities provision, "citizens of each state shall be entitled to all Privileges and Immunities of Citizens of the several states". In any discrimination by a state against citizens of another state solely on the basis of nonresidence, the discriminatory statute, regulation, or scheme will be deemed constitutional if it meets these requirements:

"Like many other constitutional provisions, the privileges and immunities clause is not an absolute. It does bar discrimination against citizens of other States where there is no substantial reason for the discrimination beyond the mere fact that they are citizens of other States. But it does not preclude disparity of treatment in the many situations where there are perfectly valid independent reasons for it. Thus the inquiry in each case must be concerned with whether the degree of discrimination bears a close relation the them. The inquiry must also, of course, be conducted with due regard for the principle that the States should have considerable leeway in analyzing local evils and in prescribing appropriate cures" (emphasis added).

Toomer v. Witsell, 334 U.S. 385 at 396 (1948).

In order to be construed as a "constitutional" limitation, therefore, any limited/reduced effort scheme developed in Louisiana must meet these enunciated parameters.

Habitat Loss

The legal protections afforded our coastal habitat by the State and Local Coastal Resources Management Act (La. R.S.49:214.21, et seq.) and the Louisiana Wetlands Conservation and Management Authority (La. R.S.49:213.1, et seq.) should be incorporated in shrimp fishery management efforts.

Shrimp Counts

While this has normally been regulated by statute, it would probably be better handled by Commission regulation, subject to legislative oversight, for management flexibility. Consideration should be given to having the federal Gulf of Mexico Fishery Management Plan amended to assist enforcement of any adopted count law as has been done in the case of Louisiana's 100 count law for white shrimp.

Magnuson Act Considerations

In the development of any limited/reduced effort scheme for the Louisiana, shrimp fishery, due care must be given to relevant provisions of the Magnuson Fishery Conservation and Management Act, 18 U.S.C. 1801, et seq. (MFCMA), particularly the "Secretarial preemption" provisions at 18 U.S.C. 1856. Any Louisiana scheme must be reviewed to ensure that it is not in conflict with and does not frustrate the attainment of the management options of the Fishery Management Plan (FMP) for the Gulf of Mexico Shrimp Fishery or any other FMP adopted under MFCMA. Also, any Louisiana limited/reduced effort scheme, the drafters of the scheme should explore how the Gulf Shrimp Plan could be used and/or amended to facilitate the Louisiana scheme, as was achieved with respect to Louisiana's 100 count for white shrimps, perhaps to pursuant to 18 U.S.C. 1853(b)(3).

Chapter 10 - Management Guidelines

Management Actions

The Louisiana Wildlife and Fisheries, at its January 1993 meeting accepted to following findings, policy, goal, and objectives as a basis for future management of Louisiana's shrimp fishery.

Findings

The Department of Wildlife and Fisheries, having reviewed the relevant scientific and technical information pertaining to Louisiana's shrimp resources, finds that:

1. Current levels of harvesting have not impacted the capacity of the resource to perpetuate itself.

2. The primary cause of variation in shrimp resource abundance is variation in habitat available to juvenile shrimp in Louisiana's coastal marshes.

3. Future deterioration and loss of coastal marshes may reduce the abundance of the shrimp resource; at such time current levels of harvest may adversely affect the resource's ability to sustain itself.

4. There are some areas of Louisiana's coastal marshes where

shrimp typically do not attain useable market size. Current statutory law and management practices allows for, if not encourages, the catch and discarding of such small, unmarketable shrimp. Elimination of the opportunity for destruction of this shrimp would likely increase total value of the resource.

5. The effect of shrimp harvesting operations on habitat and other marine resources is unclear; a major effort by state and federal agencies, and the industry, is underway to investigate these effects.

6. The major source of economic distress to shrimp harvesters is the increasing amounts of shrimp imported from other countries.

7. Considerable economic loss to the Louisiana shrimp industry occurs because much of the processing of Louisiana shrimp occurs out-of-state.

8. Current worldwide developments in shrimp mariculture prevents implementation of a management strategy assuring maximum economic return from Louisiana's shrimp harvest.

9. Current legislative mandates encourage open access to the resource and harvest of a wide range in shrimp sizes.

10. Theoretical yield per recruit models indicate that yield in terms of weight may be increased by 10-20% if minimum harvest size were increased to 80 count shrimp. However, major changes in current management practices would be required to test this hypothesis.

Policy

It is the policy of the Louisiana Wildlife and Fisheries Commission that the maximum opportunity be given to the citizens of Louisiana to harvest the marine shrimp resource, while minimizing any adverse impacts which the process of harvesting may have on habitat and on other marine resources.

Goal

The goal of shrimp management in Louisiana is to optimize the economic and cultural benefits of the marine shrimp resource to the citizens of Louisiana.

Objectives

1. Perpetuate the renewable shrimp stocks.

2. Protect and enhance the habitat required by the shrimp resource.

3. Enhance the economic benefits provided by the shrimp resource to the citizens of Louisiana.

4. Conserve the cultural heritage of the shrimp fishery.

5. Provide for the economic stability of the fishery.

6. Provide a source of fresh food for the citizens of Louisiana.

7. Minimize any verified impacts which the harvest of shrimp may have on habitat and other marine resources.

8. Reduce to the maximum extent possible waste of the resource by discouraging operations which result in culling to increase size of retained harvest.

Standards

The harvest, conservation, and management of the shrimp resource shall be in accordance to the following standards:

1. Conservation and management shall endeavor to achieve optimum yield, while preventing overfishing which may diminish future utilization of the resource.

2. Conservation and management shall be based on the best scientific and technical information available.

3. To the extent possible the shrimp resource shall be managed as a unit stock throughout its range within the state's jurisdiction; however consideration shall be given any geographic variation in abundance or other factors which may contribute to attaining the management goal.

4. If it becomes necessary to allocate or assign fishing privileges among various fishermen, such allocations to the extent possible shall be:
    a) fair and equitable to all such fishermen;
    b) reasonably calculated to promote conservation;
    c) carried out in such a manner that no particular individual, corporation, or other legal entity acquires an excessive share of such privilege;
    d) in the best interest of the citizens of Louisiana.

5. Conservation and management measures shall, where practicable, promote efficiency in the conservation and management of fishery resources; except that no such measure shall have economic allocation or maximization as its sole purpose.

6. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

7. Conservation and management measures may take into account and allow for variations among, and contingencies in, fisheries resources and catches.

Addressing the Major Problems

The following are options which can be used to address the

major problems of the Louisiana shrimp industry:

Overcapitalization/Excessive Fishing Effort

1. Increase commercial license fees.

2. Alter the license structure to create multi-year licenses.

3. Require that a harvester obtain a specified minimum percentage of his income from shrimping.

4. Create the craft of "Professional Fisherman" requiring apprenticeship, experience, and education; allow harvesting of the resource only by those who qualify.

5. Create sanctuaries in the marshes and shallow bays to reduce effort on small shrimp.

6. Institute limited entry in the fishery.

Imports

1. Continue to advise federal officials of the impacts which imports are having on the domestic shrimp industry.

2. Encourage enforcement of existing labelling laws by Louisiana's Department of Health and Hospitals.

Bycatch

1. Minimize any verified impacts which the harvest of shrimp may have on the habitat and other marine resources.

Turtle Excluder Devices (TEDs)

1. Continue to advise federal officials of the impacts which TEDs are having on the domestic shrimp industry.

Habitat Loss/Privatization

1. Encourage all marsh management plans which do not commercially harvest shrimp to set aside applicable habitat as shrimp sanctuaries.

2. Encourage pertinent state and federal agencies to address habitat loss in the estuarine system.

Development Actions

1. Encourage the Seafood Marketing and Promotion Board to investigate and publicize economic incentives available for the development of Louisiana's shrimp processing sector.

2. Encourage the Seafood Marketing and Promotion Board to publicize the healthful aspects of consuming Louisiana shrimp.

Research Needed

1. Analyze the Department's 25 year historical fishery independent shrimp/groundfish monitoring database to explore long term trends in shrimp and fish populations.

2. Collect more timely and accurate economic and social data (particularly catch and effort data), including institution of a credit card reporting system and obtaining additional boat/vessel characteristics from license data.

3. Develop fishing habits and procedures that reduce bycatch without sacrificing shrimp catch.

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Tables

Table I. Resident and nonresident commercial shrimping licenses issued by the Louisiana Department of Wildlife and Fisheries, 1977-91.

Year	Resident			Nonresident		
	Trawl	Butterfly	Total	Trawl	Butterfly	Total
1977			13,783			1,851
1978			14,830			2,338
1979			15,310			2,387
1980			16,307			2,067
1981			19,280			3,105
1982			19,648			3,387
1983			19,163			3,473
1984[a]	17,843	123	------[c]	3,645	0	3,645
1985	15,927	3,941	------	3,540	10	-----
1986	16,311	5,088	------	2,792	4	-----
1987[b]	18,807	5,103	20,150[d]	2,111	12	2,117
1988	18,033	5,026	19,337	1,909	8	1,913
1989	16,101	4,271	17,190	1,765	17	1,776
1990	14,270	4,364	16,369	1,699	16	1,711
1991	12,452	4,282	14,598	1,456	23	1,476

Source: Roberts and Pawlyk and unpublished LDWF license data.

[a] Delineation of shrimp gear licenses by type was not instituted until 1984.

[b] The numbers shown for 1987-91 are not directly comparable to previous years due to changes in licensing procedures and revised shrimp gear regulations. Effective 1987, each licensee was assigned an account number used for all their licensing activity. If, for example, a shrimper applied for different shrimp gear licenses throughout the calendar year, he is shown as one shrimper holding multiple licenses rather than a different license for each license application. This new method enables a better count of license holders in addition to number of licenses issued. The figures shown in this table for 1987-91 represent the number of people holding shrimp gear licenses. Changes in trawl size regulations also affected the number of commercial trawl licenses issued after 1986. People previously applying for recreational trawl licenses were permitted to use trawls up to 25 feet but are now required to obtain a commercial trawl license if their trawl net size exceeds 16 feet.

[c] Total, exclusive of duplication, is not available during 1984-86.

[d] The total is less than the sum of the trawl and butterfly licenses in 1987-91 because the total is exclusive of duplication. For example, 3,760 Louisiana residents were issued both trawl and butterfly gear licenses in 1987.

Table II. Vessels, Boats, and Related Number of Fishermen Shrimping in Louisiana (state and federal waters) based on National Marine Fisheries Service Estimates[a], 1977-89.

Year	Vessels		Boats			Total
	Number	Fishermen	Number	Fishermen		
				Regular	Casual	Fishermen
1977	1,663	3,931	3,849	3,363	1,725	9,019
1978	1,647	4,086	3,951	3,578	1,750	9,414
1979	1,876	4,677	4,060	3,927	1,759	10,363
1980	2,102	5,278	4,420	4,113	2,099	11,490
1981	2,253	5,768	4,469	4,094	2,157	12,019
1982	2,700	6,890	4,527	4,226	2,261	13,377
1983	2,905	7,428	4,697	3,963	2,060	13,451
1984	3,194	8,160	4,722	3,958	2,041	14,159
1985	3,455	8,601	4,510	4,115	2,245	14,961
1986	3,636	9,310	4,953	4,133	2,841	16,284
1987	3,854	10,055	6,013	5,254	2,427	17,736
1988	4,016	10,501	5,518	4,590	2,477	17,568
1989	4,073	10,791	4,940	4,927	1,933	17,651

[a] The numbers provided in this table include only otter trawl estimates. They do not include butterfly estimates. In 1989, NMFS estimated 774 fishermen on vessels (364 total vessels) and 1,475 fishermen on boats (580 total boats) using butterfly nets. Since otter trawl and butterfly activities are not mutually exclusive throughout the year, combining the otter trawl numbers and butterfly numbers would likely be misleading.

Table III. Louisiana Shrimp Gear Licenses, by Parish, 1990-91.

	1990				1991			
	Trawl	Butter-fly	Both	Total Gear Licenses	Trawl	Butter-fly	Both	Total Gear Licenses
Acadia	161	15	10	166	138	23	15	146
Allen	6	1	-----	7	4	4	-----	8
Ascension	74	11	4	81	71	16	12	75
Assumption	100	9	5	104	70	8	3	75
Avoyelles	13	1	1	13	16	3	2	17
Beauregard	18	3	2	19	16	2	2	16
Bienville	1	-----	-----	1	1	-----	-----	1
Bossier	3	-----	-----	3	1	-----	-----	1
Caddo	2	2	1	3	2	1	1	2
Calcasieu	441	185	116	510	337	154	93	398
Caldwell	-----	-----	-----	-----	-----	-----	-----	-----
Cameron	25	184	74	366	238	14	63	321
Catahoula	2	1	1	2	2	1	1	2
Claiborne	-----	-----	-----	-----	-----	-----	-----	-----
Concordia	9	1	1	9	8	2	1	9
Desoto	-----	-----	-----	-----	-----	-----	-----	-----
E. Baton Rouge	130	19	11	138	120	20	12	128
E. Carroll	1	1	-----	2	1	1	-----	2
E.Feliciana	6	-----	-----	6	4	-----	-----	4
Evangeline	51	6	4	53	45	3	2	46
Franklin	1	-----	-----	1	-----	-----	-----	-----
Grant	1	-----	-----	1	2	-----	-----	2
Iberia	462	15	10	467	452	26	5	473
Iberville	30	2	1	31	33	1	-----	34
Jackson	1	-----	-----	1	-----	-----	-----	-----

(continued)

Table III. Louisiana Shrimp Gear Licenses, by Parish, 1990-91.

	1990				1991			
	Trawl	Butter-fly	Both	Total Gear Licenses	Trawl	Butter-fly	Both	Total Gear Licenses
Jeff Davis	157	31	27	161	112	22	17	117
Jefferson	2,522	746	442	2,826	2,124	698	420	2,402
Lafayette	258	12	7	263	215	14	4	225
Lafourche	1,848	497	298	2,047	1,728	558	308	1,978
Lasalle	1	-----	-----	1	-----	-----	-----	-----
Lincoln	-----	-----	-----	-----	-----	-----	-----	-----
Livingston	113	15	10	118	81	8	6	83
Madison	-----	-----	-----	-----	-----	-----	-----	-----
Morehouse	1	-----	-----	1	2	-----	-----	2
Natchitoches	2	1	-----	3	1	1	-----	2
Orleans	639	202	138	703	526	167	118	575
Ouachita	7	-----	-----	7	5	-----	-----	5
Plaquemines	955	494	201	1,248	792	513	181	1,124
Point Coupee	13	1	1	13	10	-----	-----	10
Rapides	17	7	4	20	13	4	2	15
Red River	-----	-----	-----		-----	-----	-----	
Richland	-----	-----	-----		-----	-----	-----	
Sabine	1	-----	-----		1	-----	-----	1
St. Bernard	946	487	263	1,170	777	460	237	1,000
St. Charles	360	66	46	380	302	70	48	324
St. Helena	4	-----	-----	4	2	1	1	2
St. James	124	19	11	132	109	24	15	118
St. John	226	24	16	234	197	23	14	206
St. Landry	98	10	4	104	84	10	6	88
St. Martin	113	3	2	114	98	5	4	99
St. Mary	584	123	54	653	534	128	54	608

Table III. Louisiana Shrimp Gear Licenses, by Parish, 1990-91.

	1990				1991			
	Trawl	Butter-fly	Both	Total Gear Licenses	Trawl	Butter-fly	Both	Total Gear Licenses
St. Tammany	506	124	94	536	441	111	81	471
Tangipahoa	176	27	25	178	144	22	19	147
Tensas	-----	-----	-----	-----	-----	-----	-----	-----
Terrebonne	2,305	934	331	2,908	2,132	954	341	2,745
Union	2	-----	-----	2	2	1	1	2
Vermillion	469	79	45	503	407	68	40	435
Vernon	4	-----	-----	4	-----	-----	-----	-----
Washington	24	4	3	25	26	4	4	26
Webster	1	-----	-----	1	-----	-----	-----	-----
W. Baton Rouge	20	1	1	20	23	4	2	25
W. Carroll	-----	-----	-----	-----	-----	-----	-----	-----
W.Feliciana	3	1	1	3	3	1	1	3
Winn	-----	-----	-----	-----	-----	-----	-----	-----

Source: Unpublished Louisiana Department of Wildlife and Fisheries

Table IV. Size Distribution of Resident Commercial Shrimp Boats and Vessels in Louisiana, 1977-91 (selected years).

Year	Boat Length Class			
	< 20 ft.	20-30 ft.	> 30-50 ft.	> 50 ft.
1977	7,379	4,533	1,490	534
1979	8,000	5,204	1,608	662
1981	10,433	6,451	1,946	687
1983	9,238	7,183	2,266	739
1986	7,658	6,974	2,378	884
1987[a]	8,188	6,577	1,989	861
1988	7,786	6,702	2,117	885
1989	6,670	6,108	2,073	871
1990	5,810	5,527	1,974	825
1991	5,040	4,937	1,865	803

Source: Unpublished license data provided by the Louisiana Department of Wildlife and Fisheries.

[a] Summation of boat numbers by boat length classes since 1987 will give lower numbers than the number of resident commercial shrimp licenses issued (Table I). This reflects a change in licensing procedures effective 1987. Prior to 1987, commercial shrimpers were required to purchase one license to allow the use of both trawls and vessels in state waters. Effective in 1987, however, shrimpers were required to license their gear and vessels separately. Since gear licenses were transferrable, many people may have purchased gear licenses and not a vessel license.

Table V. Gear Use by Louisiana Shrimpers in Inshore Waters Based on Employment Status, 1987.

Boat Class	Full-time			Part-time		
	Trawl	Butterfly	Both	Trawl	Butterfly	Both
	---------- % ----------			---------- % ----------		
<20 ft.	25.0	37.5	37.5	83.8	12.7	3.5
20-30 ft.	68.2	10.0	21.8	65.6	23.4	10.9
>30-50 ft.	64.6	9.2	26.2	33.3	50.0	16.7
>50 ft.	82.6	0.0	17.4	----	----	----

Source: Keithly and Mounce (1990)

Compiled from 1987 survey data of Louisiana's inshore shrimp fleet.

Table VI. Average Number and Size of Trawls[a] Used in Louisiana Inside Waters Based on Employment Status, 1987.

Boat Class	Full-time			Part-time		
	One Trawl	Two Trawls	Avg. Size	One Trawl	Two Trawls	Avg. Size
	%	%	ft.[b]	%	%	ft.
<20 ft.	100	0	28.7	100	0	29.3
20-30 ft.	96	4	43.6	96	4	35.3
>30-50 ft.	69	31	40.3	100	0	46.0
>50 ft.	29	71	38.9			

Source: Keithly and Mounce (1990)

Compiled from 1987 survey data of Louisiana's inshore shrimp fleet.

[a] Based only on those shrimpers who indicated the use of a trawl(s) in inside waters.

[b] Size is based on headrope length.

Table VII. Louisiana, Gulf Region, and South Atlantic Shrimp Landings, 1970-90.

Year	Louisiana	Gulf Total	South Atlantic	Southeast Total	Louisiana as % of Gulf	Louisiana as % of Southeast
	----------	----------	1,000 lbs (Headless)	----------	----------	----------
1970	57,837	146,270	13,148	159,418	39.5	36.3
1971	58,712	143,653	19,563	163,216	40.9	36.0
1972	52,689	144,480	15,204	159,684	36.5	33.0
1973	37,267	115,517	15,774	131,291	32.3	28.4
1974	37,889	117,557	17,200	134,757	32.2	28.1
1970-74 avg.	48,879	133,495	16,178	149,673	36.6	32.7
1975	33,887	107,287	15,929	123,216	31.6	27.5
1976	52,148	132,069	16,622	148,691	39.5	35.1
1977	66,042	166,904	11,333	178,237	39.6	37.1
1978	66,312	155,307	11,243	166,550	42.7	39.8
1979	49,736	125,790	19,021	134,811	39.5	36.9
1975-79 avg.	53,625	137,471	14,830	152,301	39.0	35.2

Table VII. Louisiana, Gulf Region, and South Atlantic Shrimp Landings, 1970-90.

Year	Louisiana	Gulf Total	South Atlantic	Southeast Total	Louisiana as % of Gulf	Louisiana as % of Southeast
	----------	----------	1,000 lbs (Headless)	----------	----------	----------
(continued)						
1980	57,579	132,761	20,719	153,480	43.4	37.5
1981	71,333	171,390	10,571	181,961	41.6	39.2
1982	57,368	132,606	16,612	149,218	43.3	38.4
1983	48,861	126,419	16,845	143,264	38.7	34.1
1984	67,815	162,093	12,106	174,199	41.8	38.9
1980-84 avg.	60,591	145,054	15,371	160,425	41.8	37.8
1985	74,162	167,263	17,208	184,471	44.3	40.2
1986	93,767	193,493	16,286	209,779	48.5	44.7
1987	74,839	163,814	15,178	178,992	45.7	41.8
1988	65,167	142,282	16,069	158,351	45.8	41.1
1989	63,564	146,006	22,159	168,165	43.5	37.8
1985-89 avg.	74,300	162,572	17,380	179,952	45.7	41.3
1990	75,556	160,647	19,983	180,630	47.0	41.8

Source: Unpublished data provided by the National Marine Fisheries Service

Table VIII. Reported Shrimp Landings in Each of the Gulf Region States for 1970-1990, Selected Time Periods.

Time Period	State				
	Florida (West Coast)	Alabama	Mississippi	Louisiana	Texas
	--------	1,000 Pounds (Headless)		---------	
1970-74 avg.	15,762	9,422	4,476	48,879	54,959
1975-79 avg.	18,027	12,441	4,880	53,625	48,497
1980-84 avg.	16,783	10,900	6,017	60,591	50,759
1985-89 avg.	12,990	11,346	8,936	74,300	54,999
1990	8,320	9,343	9,539	75,556	57,889
1970-90 avg.	15,530	10,947	6,242	60,120	52,569

Source: Unpublished data provided by the National Marine Fisheries Service.

Table IX. Louisiana Shrimp Landings, by Size (pounds). 1970-1990.

	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
	1,000 Pounds (Headless)							
1970	1,325	3,937	4,914	4,189	6,566	3,813	8,235	22,681
1971	1,428	2,873	3,887	3,823	7,295	5,052	7,160	26,784
1972	1,266	3,249	3,274	2,495	6,149	4,433	6,552	23,718
1973	838	1,886	1,925	1,497	2,986	1,744	2,878	21,126
1974	1,063	2,172	2,305	1,605	2,872	1,718	2,660	19,945
1970-74 avg.	1,184 (2.5)[a]	2,823 (6.0)	3,261 (7.0)	2,722 (5.8)	5,174 (11.0)	3,352 (7.2)	5,497 (11.7)	22,851 (48.8)
1975	879	2,167	2,183	1,479	2,766	1,486	1,750	17,107
1976	970	2,521	3,477	3,176	4,688	2,701	5,139	28,869
1977	671	2,517	3,057	2,884	6,529	3,988	9,269	33,782
1978	679	2,570	3,429	3,082	5,474	3,343	7,682	37,409
1979	894	1,914	2,560	2,196	4,668	3,081	6,102	24,163
1975-79 avg.	818 (1.6)	2,338 (4.6)	2,942 (5.8)	2,563 (5.1)	4,825 (10.3)	2,920 (5.8)	5,989 (11.8)	28,266 (55.8)

Table IX. Louisiana Shrimp Landings, by Size (pounds). 1970-1990.

	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
	1,000 Pounds (Headless)							
1980	955	1,809	2,194	2,702	4,639	2,687	6,281	29,729
1981	767	2,495	4,153	4,629	6,975	4,251	7,001	36,834
1982	554	1,370	1,803	2,371	5,399	2,860	7,307	33,196
1983	628	1,433	1,626	2,097	4,787	3,044	6,062	25,981
1984	749	1,954	2,528	3,753	7,348	4,639	8,796	33,777
1980-84 avg.	731 (1.3)	1,812 (3.2)	2,461 (4.4)	3,110 (5.5)	5,829 (10.3)	3,496 (6.2)	7,089 (12.6)	31,903 (56.5)
1985	1,137	2,338	2,270	2,810	5,876	4,288	8,256	42,589
1986	1,395	2,782	3,570	4,391	8,054	6,845	7,061	51,067
1987	917	1,689	2,709	4,367	6,939	6,648	6,323	40,846
1988	592	1,465	2,010	2,493	5,989	6,544	8,266	34,700
1989	817	1,788	1,728	2,338	4,803	4,695	5,882	38,210
1985-89 avg.	972 (1.4)	2,012 (2.9)	2,457 (3.5)	3,280 (4.7)	6,332 (9.1)	5,804 (8.4)	7,158 (10.3)	41,482 (59.7)
1990	853 (1.2)	1,337 (1.8)	2,857 (3.9)	3,284 (4.5)	4,526 (6.2)	4,376 (6.0)	6,515 (8.9)	49,665 (67.7)
1970-90 avg.	923	2,203	2,784	2,936	5,492	3,916	6,437	32,008

[a] Numbers in parentheses represent the contribution to total state landings represented by each size class during each of the five-year periods.

Source: Unpublished date provided by the National Marine Fisheries Service

Table X. Louisiana Landings of ≥68 Shrimp by Size Count, 1985-90.

Year	Size Count				
	68-80	81-100	101-116	> 116[a]	Total[b]
	1,000 lbs (Headless)				
1985	7,063 (17.7)[c]	6,598 (16.5)	6,538 (16.4)	19,775 (49.5)	39,974
1986	7,145 (14.9)	12,727 (26.6)	7,353 (15.4)	20,677 (43.2)	47,902
1987	8,771 (22.3)	9,846 (25.1)	4,646 (11.8)	16,012 (40.8)	39,275
1988	7,563 (22.5)	9,246 (27.5)	4,119 (12.2)	12,744 (37.8)	33,672
1989	8,116 (22.0)	9,251 (25.1)	4,404 (11.9)	15,086 (40.9)	36,857
1990	10,106 (21.2)	12,364 (25.9)	8,357 (17.5)	16,878 (35.4)	47,705
1985-90 avg.	8,127 (19.9)	10,005 (24.5)	5,903 (14.4)	16,862 (41.2)	40,897

[a] Some of the reported shrimp landings in the ≥116 size count may actually fall in the 101-116 size count. This reflects the reporting procedures used in the collection of white shrimp data

[b] The total of ≥68 count shrimp to the pound reported here is less than that reported in in other tables for two reasons. First, some rounding exists in the data used in this table. Second, data in this table includes only brown and white shrimp landings.

[c] Numbers in parentheses represent the percentage of ≥68 count shrimp represented by each of the size classes in each year.

Source: Unpublished data provided by the National Marine Fisheries Service

Table XI. Louisiana's Reported Shrimp Landings by Size in Relation to the Gulf Region.

1970-74 avg.								
Louisiana	1,184	2,823	3,261	2,722	5,174	3,352	5,497	22,851
Gulf	2,832	13,140	15,610	13,666	25,653	13,125	16,384	29,642
% Louisiana	41.8	21.5	20.9	19.9	20.2	25.5	33.6	77.1
1975-79 avg.								
Louisiana	818	2,338	2,942	2,563	4,825	2,920	5,989	28,266
Gulf	1,992	10,250	14,319	12,387	25,221	13,109	20,761	38,801
% Louisiana	41.1	22.8	20.5	20.7	19.1	22.3	28.9	72.8
1980-84 avg.								
Louisiana	731	1,812	2,461	3,110	5,829	3,496	7,089	31,903
Gulf	1,632	9,037	11,474	12,892	23,504	12,849	19,492	47,814
% Louisiana	44.8	20.1	21.4	24.1	24.8	27.2	36.4	66.7
1985-89 avg.								
Louisiana	972	2,012	2,457	3,280	6,332	5,804	7,158	41,482
Gulf	3,326	11,877	11,678	11,152	21,357	15,822	18,117	61,166
% Louisiana	29.2	16.9	21.0	29.4	29.6	36.7	39.5	67.8
1990								
Louisiana	853	1,337	2,857	3,284	4,526	4,376	6,515	49,665
Gulf	3,769	10,386	11,701	11,075	19,528	13,759	16,087	69,420
% Louisiana	22.6	12.9	24.4	29.7	23.2	31.8	40.5	71.5
1970-90 avg.								
Louisiana	923	2,203	2,784	2,936	5,492	3,916	6,437	32,008
Gulf	2,508	11,043	13,195	12,455	23,724	13,728	18,565	45,549
% Louisiana	36.8	19.9	21.1	23.6	23.2	28.5	34.7	70.3

Source: Unpublished data provided by the National Marine Fisheries Service

Table XII. Louisiana Shrimp Landings by Species, 1970-1990.

Year	Species			
	Brown	White	Other[a]	Total[b]
	1,000 lbs			
1970	26,976	28,698	2,163	57,837
1971	29,368	29,005	340	58,713
1972	27,090	24,092	1,507	52,689
1973	18,074	16,846	2,350	37,270
1974	17,552	16,876	3,464	37,892
1970-74 avg.	23,812 (48.7)[c]	23,103 (47.3)	1,965 (4.0)	48,880 (100.0)
1975	14,077	15,770	4,039	
1976	28,942	22,691	515	52,148
1977	33,849	28,898	3,270	66,017
1978	34,749	29,064	2,500	66,313
1979	27,046	18,842	3,847	49,735
1975-79 avg.	27,733 (51.6)	23,053 (42.9)	2,924 (5.4)	53,710 (100.0)
1980	21,370	29,705	6,504	57,579
1981	35,663	31,541	4,130	71,334
1982	31,522	23,478	2,368	57,368
1983	24,807	21,436	3,128	49,371
1984	33,778	29,826	4,211	67,815
1980-84 avg.	29,428 (48.5)	27,197 (44.8)	4,068 (6.7)	60,693 (100.0)
1985	34,676	34,969	4,414	74,059
1986	38,772	46,455	8,312	93,539
1987	36,214	34,430	4,195	74,839
1988	32,595	29,454	2,938	64,987
1989	34,375	26,092	3,197	63,664
1985-89 avg.	35,326 (47.6)	34,280 (46.2)	4,611 (6.2)	74,217 (100.0)
1990	44,611	29,002	1,943	75,556

[a] Totals may not equal Louisiana landings presented in Table 3.2.1 due to rounding.

[b] Other includes rock shrimp, sea bobs, and pink shrimp.

[c] Numbers in parentheses represent the contribution to total state shrimp landings by each species.

Source: Unpublished data provided by the National Marine Fisheries Service

Table XIII. Percent Size Distribution of Louisiana's Brown and White Shrimp Landings, 1975-90.

	Brown Shrimp			White Shrimp		
Year	≤30 ct.	31-67 ct.	≥68 ct.	≤30 ct.	31-67 ct.	≥68 ct.
1970	15.1	32.2	52.7	35.9	34.7	29.4
1971	15.8	27.7	61.1	30.2	39.2	30.3
1972	13.2	33.8	52.8	27.8	32.9	39.0
1973	9.9	11.8	78.1	25.7	32.2	41.6
1974	11.3	13.9	74.5	30.5	28.4	40.7
1975	12.87	13.11	73.77	30.82	26.21	42.62
1976	7.42	17.82	74.59	35.15	32.42	32.08
1977	6.03	29.28	64.55	24.44	34.08	41.27
1978	4.29	20.54	75.02	28.44	32.17	38.99
1979	4.99	24.03	70.44	32.97	39.02	27.10
1980	4.38	16.52	77.24	21.41	33.92	44.50
1981	6.04	20.32	73.48	31.31	34.79	33.67
1982	5.01	21.59	73.14	19.24	37.31	43.19
1983	4.34	17.09	78.35	22.39	46.11	31.19
1984	4.75	25.30	69.92	24.74	41.02	34.06
1985	4.33	18.36	77.08	20.14	34.45	45.06
1986	6.83	16.52	76.29	20.41	33.45	45.80
1987	6.06	19.70	73.96	21.75	37.10	40.84
1988	7.69	30.74	61.26	13.66	36.34	49.57
1989	7.01	22.35	70.38	16.34	29.56	53.97
1990	3.83	14.67	81.49	22.87	30.70	46.43

Source: Unpublished data provided by the National Marine Fisheries Service.

Note: Pieces are not included in the above figures. Therefore, summation of percentages will give slightly less than 100.0.

Table XIV. Size Distribution of Louisiana ≥68 Count Landings of "Small" Shrimp by Species (Brown and White), 1985-90.

Year	68-80 ct.	81-100 ct.	101-116 ct.	≥116 ct.
	%			
		Brown Shrimp		
1985	13.4	13.5	16.9	56.2
1986	11.8	20.8	26.2	41.2
1987	24.7	23.2	18.0	34.1
1988	20.9	22.2	20.8	36.0
1989	22.0	24.2	18.2	35.6
1990	20.7	22.0	24.1	33.2
		White Shrimp		
1985	25.5	22.1	15.6	38.2
1986	19.4	34.7	--[a]	45.9
1987	17.8	28.7	--	53.6
1988	24.7	34.9	--	40.4
1989	22.1	26.7	--	51.0
1990	22.4	36.6	--	41.1

[a] Since 1986, the 101-116 white shrimp count has been included in the ≥116 count category (personal communications Dr. Jim Nance, NMFS)

Source: Unpublished data provided by the National Marine Fisheries Service.

Table XV. Louisiana Landings of Shrimp by Inshore and Offshore Waters, 1976-90.

Year	Inshore	Offshore		Total
		State	Federal	
	---------- 1,000 lbs. (headless) ----------			
1976	25,742	16,144	10,262	52,148
1977	29,568	24,754	11,594	65,917
1978	22,595	26,396	17,321	66,312
1979	17,420	21,140	11,176	49,736
1980	16,940	31,665	8,961	57,566
1976-80 avg.	22,435 (38.5)[a]	24,020 (41.2)	11,863 (20.3)	58,336
1981	27,618	31,035	11,880	70,533
1982	26,529	21,696	9,143	57,368
1983	21,399	19,755	8,217	49,371
1984	29,706	23,088	15,021	67,815
1985	27,158	34,347	12,555	74,060
1981-85 avg.	26,487 (41.8)	25,984 (40.7)	11,363 (17.8)	63,829
1986	36,385	42,791	14,363	93,539
1987	27,899	33,230	13,710	74,839
1988	30,526	23,544	10,917	64,987
1989	23,707	30,337	9,620	63,664
1990	29,956	46,135	5,512	81,603
1986-90 avg.	29,695 (39.2)	35,207 (46.5)	10,824 (16.8)	75,726
1976-90 avg.	26,206 (39.7)	28,403 (43.1)	11,350 (17.2)	65,964

Source: Unpublished data provided by the National Marine Fisheries Service.

[a] Numbers in parentheses refer to the proportion total state landings represented by inshore and offshore landings, respectively, in each five-year interval.

Table XVI. Louisiana Reported Shrimp Landings by Parishes, 1976-90.

Year	Cameron	Vermilion	Terrebonne	Jefferson	Lafourche	St. Bernard	Plaquemine	Other[a]	Total
					1,000 lbs.				
1976	4,102	5,544	16,315	9,845	7,675	1,330	5,627	1,710	52,148
1977	4,211	6,557	22,953	12,569	9,859	1,286	6,975	1,632	66,042
1978	4,929	8,272	21,845	10,628	9,642	1,504	7,898	1,594	66,312
1979	3,788	3,510	17,151	8,644	6,824	1,840	7,012	967	49,736
1980	4,626	5,205	21,423	8,235	6,904	1,557	8,778	851	57,579
1976-80 avg.	4,331 (7.4)[b] (100.0)	5,818 (10.0)	19,937 (34.1)	9,984 (17.1)	8,181 (14.0)	1,503 (2.6)	7,258 (12.4)	1,351 (12.4)	58,363 (2.3)
1981	6,218	6,743	24,676	12,259	8,514	1,881	10,036	1,006	71,333
1982	5,135	6,220	17,734	9,366	6,284	3,135	7,747	1,747	57,368
1983	3,740	3,625	14,093	8,404	5,878	3,050	9,443	628	48,861
1984	5,072	5,142	21,646	11,888	6,733	4,616	11,039	1,679	67,815
1985	5,725	5,996	24,547	13,995	7,822	4,649	10,105	1,323	74,162
1981-85 avg.	5,178 (8.1)	5,545 (8.7)	20,539 (32.1)	11,182 (17.5)	7,046 (11.0)	3,466 (5.4)	9,674 (15.1)	1,278 (2.0)	63,908 (100.0)

Table XVI. Louisiana Reported Shrimp Landings by Parishes, 1976-90.

Year	Cameron	Vermilion	Terrebonne	Jefferson	Lafourche	St. Bernard	Plaquemine	Other[a]	Total
					1,000 lbs.				
1986	6,537	10,318	31,148	15,146	12,238	4,210	12,231	1,939	93,767
1987	4,293	9,743	22,733	10,880	8,819	3,960	12,067	2,344	74,839
1988	4,261	4,917	19,005	7,478	7,570	3,146	11,862	6,928	65,167
1989	2,771	4,545	21,133	9,396	7,950	2,825	10,481	4,463	63,564
1990	3,951	5,995	22,842	11,605	8,547	3,958	13,389	5,269	75,556
1986-90 avg.	4,363 (5.9)	7,104 (9.5)	23,372 (31.3)	10,901 (14.6)	9,025 (12.1)	3,620 (4.9)	12,006 (16.1)	4,188 (5.6)	74,579 (100.0)

Source: Unpublished data provided by the National Marine Fisheries Service.

[a] Other parishes include Orleans, Jefferson Davis, St. Mary, St. Tammany, and Tangipahoa.

Table XVII. Louisiana Shrimp Landings by Gear Type, 1985-90.

Year	Gear Type	
	Trawl	Butterfly[a]
1985	71,783	2,379
1986	87,789	5,978
1987	67,379	7,460
1988	59,251	5,916
1989	59,734	3,830
1990	69,929	5,674
1985-90 avg.	69,311	5,206

Source: Unpublished data provided by the National Marine Fisheries Service.

[a] May include small amounts of landings from other gears such as cast nets.

Table XVIII. Average Level of Effort[a] Expended by Full- and Part-Time Commercial Shrimpers During 1987, by Employment Status

Boat Class	Full-time			Part-time		
	Total Tips	Days per Trip[b]	Total Days	Total Trips	Days per Trip	Total Days
<20 ft.	45.1(8)[c]	1.00	45.1	15.4(173)	1.03	15.8
20-30 ft.	65.4(110)	1.25	81.8	24.6(128)	1.07	26.3
>30-50 ft.	46.9(65)	2.04	95.5	28.2(6)	1.80	50.8
>50 ft.	27.0(23)	4.50	120.3			

Source: Keithly and Mounce (1990).

[a] Based on all shrimpers surveyed.

[b] The term "days per trip" refers to the number of calendar days the boat was absent from port, and does not make any assumptions as to the length of time spent during the day shrimping.

[c] Numbers in parentheses indicate the number of shrimpers surveyed.

Table XIX. Shrimping Effort Among Full-time and Part-time Louisiana Commercial Shrimpers, Delineated by Inshore and Offishore Waters, 1987.

	Inshore Effort								
	Brown Shrimp Season			White Shrimp Season			Total Combined		
Boat Class	Trips	Days/ Trip	Total Days	Trips	Days/ Trip	Total Days	Trips	Days/ Trip	Total Days
				Full-time Shrimpers					
<20 ft.	28.1(7)[a]	1.0	28.1	27.3(6)	1.0	27.3	45.1(8)	1.0	45.1
20-30 ft.	30.4(108)	1.2	36.3	32.9(106)	1.2	40.9	61.4(110)	1.2	74.7
>30-50 ft.	18.6(65)	2.0	36.5	25.0(64)	2.2	54.1	43.1(65)	2.1	89.7
>50 ft.	10.9(22)	2.8	30.8	8.0(21)	4.8	38.2	17.7(23)	3.6	64.3
				Part-time Shrimpers					
<20 ft.	8.2(173)	1.0	8.4	7.6(159)	1.0	7.8	15.2(173)	1.0	15.6
20-30 ft.	14.8(127)	1.1	15.9	11.8(104)	1.1	12.6	24.3(128)	1.1	26.0
>30 ft.	12.0(4)	1.5	18.3	17.2(6)	1.6	26.7	25.2(6)	1.5	38.8

Source: Keithly and Mounce (1990).

[a] Numbers in parentheses represent the number of boats engaged in specific activity. Averages, therefore, were based only on those shrimpers participating in the specific seasons -- not by the total sample size of shrimpers in each boat class. Among full-time shrimpers, 8 boats were <20 feet in length, and 23 boats were >50 feet. Among part-time shrimpers, 173 used boats <20 feet in length, 128 boats were 20-30 feet in length, and 6 boats exceeded 30 feet in length. waters were open, and total days spent offshore by this group averaged only 23.4.

Table XIX. Continued.

Boat Class	Offshore Effort: Inshore Waters Open			Offshore Effort: Inshore Waters Closed			Total Combined		
	Trips	Days/ Trip	Total Days	Trips	Days/ Trip	Total Days	Trips	Days/ Trip	Total Days
				Full-time Shrimpers					
<20 ft.	--------	---	--------	--------	---	----	--------	---	----
20-30 ft.	23.9(10)	1.8	43.7[60][b]	14.4(14)	1.7	24.4	25.9(17)	1.8	45.8
>30-50 ft.	13.9(11)	1.7	23.4[52]	5.5(16)	1.3	7.4	15.1(16)	1.6	23.5
>50 ft.	10.7(14)	6.4	68.9[65]	5.9(11)	5.0	29.4	14.3(15)	6.0	85.9
				Part-time Shrimpers					
<20 ft.	17.0(1)	1.0	17.0	8.5(2)	1.0	8.5	17.0(2)	1.0	17.0
20-30 ft.	10.5(2)	1.0	10.5	20.0(1)	1.0	20.0	20.5(2)	1.0	20.5
>30 ft.	10.0(1)	4.0	40.0	4.0(1)	5.0	20.0	14.0(1)	4.3	60.0

[b] Numbers in brackets represent the proportion of days engaged shrimping offshore while inside waters were open that occurred during the white shrimp season. For example, 14 of the 23 full-time shrimpers of boats greater than 50 ft. in length each spent an average 68.9 days shrimping offshore when inside waters were open to shrimping. Sixty-five percent of these days occurred during the white shrimp season. Because of the small sample sizes, these numbers were not computed for part-time shrimpers.

Table XX. Estimated Average Number of Hours per Day Spent Shrimping[a] in Louisiana Inside Waters, by Employment Status, 1987.

Shrimping Season	<20 ft.	20-30 ft.	>30-50 ft.	>50 ft.
	7.9	10.1	10.6	12.6
Brown shrimp season				
White shrimp season	9.2	9.9	10.1	10.9
Combined	8.5	10.0	10.3	11.8
	----------Part-time Shrimpers----------			
Brown shrimp season	8.8	8.3	8.2	
White shrimp season	8.7	8.4	7.9	
Combined	8.8	8.3	8.0	

Source: Keithly and Mounce (1990).

[a] Does not include running time, down time, etc. and pertains only to shrimping time in inside waters.

Table XXI. Annual Number of Shrimp Trips Related to Landings and Catch in Louisiana's Inshore and Offshore Waters, 1981-90.

	Inshore		Offshore			
			State		Federal	
	Landings	Catch	Landings	Catch	Landings	Catch
	1,000's					
1981	138.1	139.6	47.8	50.3	3.7	7.2
1982	120.9	125.0	31.2	35.3	3.6	6.6
1983	115.8	124.9	29.4	33.2	3.8	6.4
1984	141.9	160.6	26.9	29.8	8.2	11.8
1985	110.0	119.1	28.9	32.1	5.2	9.4
1986	159.3	162.4	43.1	47.2	6.9	11.6
1987	156.8	163.8	53.5	57.1	9.2	13.1
1988	158.1	163.3	30.3	33.7	6.9	10.2
1989	95.7	100.7	34.2	37.3	5.6	9.5
1990	104.7	110.3	39.0	40.8	2.3	5.0

Source: Unpublished data provided by the National Marine Fisheries Service.

a A change in data collection techniques during 1976-80 limits the use of trip data for the period.

Table XXII. Catch per Trip from Louisiana's Inshore and Offshore Waters, 1981-90.

	Catch Per Trip								
	Inshore			Offshore State			Federal Waters		
	Pounds	Current Value	Deflated Value	Pounds	Current Value	Deflated Value	Pounds	Current Value	Deflated Value
1981	200	266	241	660	1,325	1,201	3,211	9,937	9,003
1982	219	420	359	695	1,732	1,479	2,568	10,893	9,302
1983	185	380	314	672	1,825	1,510	2,162	9,081	7,511
1984	209	311	247	860	1,817	1,441	1,832	6,101	4,838
1985	247	317	246	1,188	2,061	1,596	2,414	7,756	6,008
1986	228	373	280	992	2,083	1,565	2,067	8,207	6,166
1987	178	379	275	621	1,412	1,024	1,490	5,326	3,862
1988	193	342	238	777	1,815	1,264	1,580	5,760	4,011
1989	248	409	272	887	1,722	1,144	1,730	5,782	3,842
1990	286	471	297	1,183	2,168	1,368	2,396	8,387	5,292

Source: Compiled from unpublished data provided by the National Marine Fisheries Service.

[a] Estimates of catch per trip reported in this table are based on landings data. The use of catch data, however, would not significantly affect estimates.

[b] Based on 1980 Consumer Price Index.

Table XXIII. Average Catch (heads-on) and Value per Trip[a] of Shrimp Taken in Louisiana Waters, by Employment Status, 1987.

Boat Class	Inshore		Offshore		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
	----------Full-time Shrimpers----------					
<20 ft.	198(8)[b]	$187	------	-----	198(8)	$187
20-30 ft.	257(110)	$321	171(17)	$240	250(110)	$313
>30-50 ft.	458(65)	$606	278(16)	$492	441(65)	$592
>50 ft.	1,412(23)	$1,943	1,445(15)	$2,383	1,423(23)	$2,095
	----------Part-time Shrimpers----------					
<20 ft.	112(173)	$167	291(2)	$122	114(173)	$166
20-30 ft.	151(128)	$188	146(2)	$328	152(128)	$191
>30-50 ft.	358(6)	$396	800(1)	$1,600	386(6)	$487

Source: Keithly and Mounce.

[a] Based only on those shrimpers surveyed who indicated taking the specified offshore trips.

[b] Numbers in parentheses are the sample size of shrimpers taking shrimping trips.

Table XXIV. Quantity and Value of Shrimp Processing Activities in Louisiana and the Gulf Region, Selected Periods 1973-90.

	Louisiana			Gulf Region		
		Value			Value	
Time Period	Pounds[a]	Current	Deflated[b]	Pounds	Current	Deflated
	1,000s	----- $1,000 -----		1,000s	----- $1,000 -----	
1973-75 avg.	44,098	70,520	189,298	157,538	296,893	798,905
1976-78 avg.	55,086	116,889	250,067	206,778	550,359	1,176,600
1979-81 avg.	44,463	124,781	201,545	198,702	702,203	1,130,208
1982-84 avg.	39,046	124,903	163,637	210,731	850,481	1,111,873
1985-87 avg.	50,699	141,295	167,315	245,578	908,581	1,076,866
1988-90 avg.	48,013	126,387	133,259	253,058	884,966	930,398

Source: Compiled from data provided by the National Marine Fisheries Service, Fisheries Statistics Division.

[a] All product-weight poundage has been converted to a headless, shell-on equivalent basis for purposes of analysis.

[b] The deflated value is based on the 1990 Consumer Price Index.

Table XXV. Quantity and Value of Shrimp Processing Activities in Louisiana and the Gulf Region on a Per Establishment Basis.

	Louisiana			Gulf Region		
		Value			Value	
Time Period	Pounds[a]	Current	Deflated[b]	Pounds	Current	Deflated
	1,000s	----- $1,000 -----		1,000s	---- $1,000s ----	
1973-75 avg.	843	1,348	3,617	1,176	2,216	5,962
1976-78 avg.	1,008	2,138	4,574	1,567	4,169	8,914
1979-81 avg.	866	2,431	3,926	1,594	5,633	9,066
1982-84 avg.	887	2,839	3,719	1,672	6,750	8,824
1985-87 avg.	1,071	2,985	3,535	2,075	7,678	9,100
1988-90 avg.	1,091	2,872	3,029	2,158	7,542	7,930

Source: Compiled from data provided by the National Marine Fisheries Service, Fisheries Statistics Division.

[a] All product-weight poundage has been converted to a headless, shell-on equivalent weight basis for purposes of analysis.

[b] Based on the 1990 Consumer Price Index.

Table XXVI. Selected Statistics Related to Louisiana Shrimp Processing Activities of Specific Product Forms, 1973-90.

Time Period	# Firms	Pounds[a]	Value		Price	
			Current	Deflated[b]	Current	Deflated[c]
		1,000s	----- $1,000s -----		----- $/lb. ------	
			Raw Headless			
1973-75 avg.	21	16,617	35,352	94,166	2.13	5.67
1976-78 avg.	23	22,973	65,460	139,777	2.85	6.08
1979-81 avg.	24	16,851	63,225	103,046	3.75	6.12
1982-84 avg.	25	15,618	67,747	88,652	4.34	5.68
1985-87 avg.	29	23,073	86,017	101,982	3.73	4.42
1988-90 avg.	28	17,146	65,835	69,773	3.84	4.07
			Peeled (Raw and Cooked)			
1973-75 avg.	17	5,497	7,104	18,887	1.29	3.44
1976-78 avg.	25	8,687	14,858	31,513	1.71	3.63
1979-81 avg.	20	9,889	21,143	34,014	2.14	3.44
1982-84 avg.	20	11,770	27,152	35,737	2.31	3.04
1985-87 avg.	21	18,942	36,929	43,636	1.95	2.30
1988-90 avg.	20	24,531	47,889	49,858	1.95	2.03

Table XXVI. Selected Statistics Related to Louisiana Shrimp Processing Activities of Specific Product Forms, 1973-90.

Time Period	# Firms	Pounds[a]	Value		Price	
			Current	Deflated[b]	Current	Deflated[c]
		1,000s	----- $1,000s -----		----- $/lb. ------	
				Breaded		
1973-75 avg.	11	1,050	3,010	8,105	2.87	7.72
1976-78 avg.	9	818	2,933	6,343	3.58	7.75
1979-81 avg.	5	397	1,798	2,981	4.53	7.52
1982-84 avg.	3	188	933	1,221	4.96	6.49
1985-87 avg.	3	127	628	748	4.93	5.88
1988-90 avg.	3	135	643	682	4.76	5.06
				Other		
1973-75 avg.	25	20,933	25,054	68,140	1.20	3.26
1976-78 avg.	21	22,608	33,638	72,433	1.49	3.20
1979-81 avg.	22	17,326	38,616	61,504	2.23	3.55
1982-84 avg.	18	11,471	29,071	38,027	2.53	3.32
1985-87 avg.	17	8,558	17,721	20,949	2.07	2.45
1988-90 avg.	13	6,202	12,020	12,946	1.94	2.09

[a] Pounds associated with each product has been converted to a headless, shell-on equivalent weight basis for purposes of comparison

[b] Based on the 1990 Consumer Price Index

[c] Prices of the different products are on the basis of a headless, shell-on equivalent weight product

Source: Compiled from unpublished data provided by the National Marine Fisheries Service

Table XXVII. Selected Statistics Related to Louisiana Shrimp Processing Activities of Specific Product Forms on a Per Establishment Basis.

Time Period	Pounds	Value	
		Current	Deflated
	1,000s	----------$1,000s----------	
		Raw Headless	
1973-75	778	1,665	4,420
1976-78	1,011	2,881	6,158
1979-81	714	2,681	4,373
1982-84	625	2,710	3,546
1985-87	802	2,985	3,546
1988-90	611	2,339	2,474
		Peeled (Raw and Cooked)	
1973-75	322	418	1,117
1976-78	358	605	1,302
1979-81	488	1,045	1,681
1982-84	599	1,371	1,801
1985-87	881	1,708	2,020
1988-90	1,214	2,371	2,467
		"Other"	
1973-75	844	1,014	2,759
1976-78	1,194	1,793	3,792
1979-81	791	1,762	2,799
1982-84	637	1,615	2,113
1985-87	503	1,042	1,232
1988-90	447	844	905

Table XXVIII. Monthly and Annual Employment in Louisiana's Shrimp Processing Sector[a], 1985-90.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
1985	850	629	571	586	1,283	1,600	1,470	1,162	1,218	1,186	1,087	1,135	1,065
1986	814	629	574	558	1,322	1,671	1,523	1,325	1,316	1,458	1,429	1,390	1,167
1987	853	634	601	556	1,220	1,831	1,528	1,277	1,298	1,276	1,068	1,088	1,103
1988	745	542	552	579	1,115	1,559	1,082	1,076	1,020	1,116	1,106	1,057	962
1989	613	575	583	642	1,120	1,486	1,041	974	941	948	968	987	907
1990	578	534	549	553	1,109	1,281	1,048	985	1,012	955	989	989	882
Avg.	742	591	572	579	1,195	1,571	1,282	1,133	1,134	1,157	1,108	1,108	1,014

Source: Unpublished National Marine Fisheries Service Data, Fisheries Statistics Division.

[a] Number of employees also include those shrimp plants that process other products.

Table XXIX. Fish Identified by Gunter(1945) or Darnell (1958) as feeding on penaeid shrimp

Species	Common Name
Carcharhinus leucas (Miller and Henle)	Bull Shark
Dasyatis sabina (LeSueur)[1]	Stingaree
Lepisosteus spatula (Lacepede)	Alligator Gar
Elops saurus (Linnaeus)	Bonefish, Shipjack, Bigeye, Herring, Ten-Pounder
Ictalurus furcatus (Leseur)	Blue Catfish
Bagre marina (Mitchell)	Gafftopsail Catfish
Galeichthys felis (Linnaeus)	Hardhead or Sea Cat
Morone omterrilta (Gill)	Yellow Bass
Microptirus s. salmoides (Lacepede)[1]	Northern Large-mouth bass
Sciaenopos ocellata (Linnaeus)	Redfish, Channel Drum
Micropogon undulatus (Linnaeus)[1]	Atlantic Croaker
Pogonias cromis (Linnaeus)[2]	Black Drum
Cynoscion nebulosus (Cuvier and Valenciennes)[34]	Speckled Trout
Paralichthys lethostigma (Jordan and Gilbert)	Southern Flounder

1 Assumed to ingest shrimp by Darnell (1958).

2 Darnell (1958) states that when Black Drum are in the marine waters gulf penaeid shrimp are a significant portion of its diet.

3 Gunter (1945) states that in Texas shrimp are the predominate food of Speckled Trout during the summer. However, when shrimp are scarce, as in January, Speckled Trout shift to fish (Mugil species).

4 Darnell (1958) states that pink shrimp are the staple diet of Speckled Trout in Florida.

Table XXX.

THIS TABLE NUMBER NOT USED.

Table XXXI. Louisiana, Gulf Region, and South Atlantic Shrimp Landings, 1970-90.

Year	Louisiana	Gulf Total	South Atlantic	Southeast Total	Louisiana as % of Gulf	Louisiana as % of Southeast
	----------1,000 Dollars----------					
1970	$ 34,612	$ 109,162	$ 11,387	$ 120,549	31.7	28.7
1971	43,284	136,821	20,614	157,435	31.6	27.5
1972	47,064	164,803	17,493	182,296	28.6	25.8
1973	44,507	172,984	26,638	199,622	25.7	22.3
1974	32,195	147,430	18,338	165,768	21.8	19.4
1970-74 avg.	40,332	146,240	18,894	165,134	27.6	24.4
1975	40,971	178,622	30,305	208,927	22.9	19.6
1976	79,660	274,864	34,708	309,572	29.0	25.7
1977	87,183	297,684	24,343	322,027	29.3	27.1
1978	100,848	318,635	31,432	350,067	31.7	28.8
1979	122,681	387,036	65,836	452,872	31.7	27.1
1975-79 avg.	86,269	291,368	37,325	328,693	29.6	26.2
1980	120,980	342,584	58,930	401,514	35.3	30.1
1981	136,465	405,417	32,215	437,632	33.7	31.2
1982	143,698	426,866	62,358	489,224	33.7	29.4
1983	130,912	415,849	62,194	478,043	31.5	27.4
1984	143,064	431,021	33,095	464,116	33.2	30.8

Table XXXI. Louisiana, Gulf Region, and South Atlantic Shrimp Landings, 1970-90.

Year	Louisiana	Gulf Total	South Atlantic	Southeast Total	Louisiana as % of Gulf	Louisiana as % of Southeast
			1,000 Dollars			
1980-84 avg.	135,024	404,347	49,758	454,105	33.4	29.7
1985	135,196	405,976	53,318	459,294	33.3	29.4
1986	206,658	565,956	65,231	631,187	36.5	32.7
1987	184,222	477,561	45,872	523,433	38.6	38.6
1988	149,605	409,445	55,401	464,846	36.5	32.2
1989	130,154	385,278	57,284	442,562	33.8	29.4
1985-89 avg.	161,167	448,843	55,421	504,264	35.9	32.0
1990	152,982	415,482	60,137	475,619	36.8	32.2

Source: Unpublished data provided by the National Marine Fisheries Service

Table XXXII. Current and Deflated Price of Louisiana Shrimp Landings and Consumer Price Index (1980-100)

	Current Price	Consumer Price Index (1980-100)	Deflated Price
	($/lb.)		($/lb.)
1970	0.60	0.471	1.27
1971	0.74	0.491	1.50
1972	0.89	0.508	1.76
1973	1.19	0.539	2.22
1974	0.85	0.598	1.42
1970-74 avg.	0.83	-----	1.60
1975	1.21	0.653	1.85
1976	1.53	0.691	2.21
1977	1.32	0.733	1.80
1978	1.52	0.791	1.92
1979	2.47	0.881	2.80
1975-79 avg.	1.61	-----	2.10
1980	2.10	1.00	2.10
1981	1.91	1.10	1.73
1982	2.50	1.17	2.14
1983	2.68	1.21	2.22
1984	2.11	1.26	1.67
1980-84 avg.	2.23	-----	1.94
1985	1.82	1.29	1.41
1986	2.20	1.33	1.66
1987	2.46	1.38	1.79
1988	2.30	1.44	1.60
1989	2.05	1.50	1.36
1985-89 avg.	2.17	-----	1.57
1990	2.02	1.58	1.28

Source: Unpublished data provided by the National Marine Fisheries Service.

Table XXXIII. Deflated Value of Shrimp Landings in Louisiana, the Gulf Region, and the South Atlantic, 1970-90 (1980 CPI=100)

Year	Louisiana	Gulf Total	South Atlantic
	----------1,000 Dollars----------		
1970	$ 73,486	$ 231,766	$ 24,176
1971	88,155	278,658	41,984
1972	92,646	324,415	34,435
1973	82,572	320,935	49,421
1974	53,838	246,538	30,666
1970-74 avg.	78,149	280,462	36,136
1975	62,743	273,541	46,409
1976	115,282	397,777	50,229
1977	118,616	405,012	33,120
1978	127,494	402,826	39,737
1979	139,252	439,314	74,729
1975-79 avg.	112,677	383,694	48,845
1980	120,980	342,584	58,930
1981	123,643	367,325	29,188
1982	122,714	364,531	53,252
1983	108,281	343,961	51,443
1984	113,453	341,809	26,245
1980-84 avg.	117,814	352,042	43,812
1985	104,722	314,466	41,300
1986	155,265	425,211	49,009
1987	133,591	346,310	33,265
1988	104,182	285,129	38,580
1989	86,556	256,220	38,095
1985-89 avg.	116,863	325,467	40,050
1990	96,532	262,169	37,946

Source: Unpublished data provided by the National Marine Fisheries Service

Table XXXIV. Deflated Value and Deflated Prices of Shrimp Landings in Each of the Gulf Region States, Selected Time Periods, 1970-90.

Time Period	State				
	Florida (West Coast)	Alabama	Mississippi	Louisiana	Texas
	Value ($1,000s)				
1970-74 avg.	33,339	26,533	7,543	78,149	134,906
1975-79 avg.	51,130	42,648	12,497	112,677	164,741
1980-84 avg.	42,072	33,185	14,115	117,814	144,857
1985-89 avg.	29,578	29,256	18,702	116,863	131,069
1990	15,994	19,541	16,216	96,532	113,887
	Price ($/lb.)				
1970-74 avg.	2.12	2.82	1.69	1.60	2.43
1975-79 avg.	2.84	3.43	2.56	2.10	3.40
1980-84 avg.	2.51	3.04	2.35	1.94	2.85
1985-89 avg.	2.28	2.58	2.09	1.57	2.38
1990	1.92	2.09	1.70	1.28	1.97

Source: Unpublished data provided by the National Marine Fisheries Service.

Table XXXV. Reported Value of Louisiana Shrimp Landings, by Size, 1970-90.

Year	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
				$ 1,000				
1970	1,818	4,944	5,489	4,006	5,190	2,402	3,750	6,698
1971	2,655	5,105	6,132	4,899	7,395	4,167	4,707	8,110
1972	2,529	6,235	5,687	3,987	7,960	4,198	5,000	10,948
1973	1,836	4,365	4,560	3,262	5,579	2,700	3,838	16,858
1974	2,990	5,014	4,261	2,512	3,378	1,533	2,014	9,018
1970-74 avg.	2,366	5,133	5,226	3,733	5,900	3,000	3,862	10,326
	(5.9)	(12.9)	(13.2)	(9.4)	(14.9)	(7.6)	(9.8)	(26.1)
1975	2,547	6,336	6,091	3,725	5,884	2,404	2,221	10,109
1976	4,087	10,005	11,957	9,152	11,264	4,845	6,822	21,185
1977	2,789	9,022	9,095	7,680	13,846	6,392	11,297	25,620
1978	3,058	10,467	12,609	10,014	15,142	7,290	11,946	29,058
1979	5,188	10,810	13,519	10,733	18,967	9,659	15,066	34,637
1975-79 avg.	3,534	9,328	10,654	8,261	13,021	6,118	9,471	24,122
	(4.2)	(11.0)	(12.6)	(9.8)	(15.4)	(7.2)	(11.2)	(28.5)

(continued)

Table XXXV. Reported Value of Louisiana Shrimp Landings, by Size, 1970-90.

Year	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
				$ 1,000				
1980	4,340	7,759	9,003	9.980	14,566	7,271	13,422	41,106
1981	4,275	13,098	18,248	16,077	19,705	9,869	13,518	38,756
1982	3,561	8,362	10,230	12,733	23,703	10,000	19,861	52,993
1983	4,168	9,097	9,541	10,772	21,399	11,284	17,438	44,923
1984	5,125	11,812	12,100	15,232	22,990	11,779	19,026	42,469
1980-84 avg.	4,294	10,025	11,824	12,959	20,473	10,042	16,653	44,049
	(3.3)	(7.7)	(9.1)	(9.9)	(15.7)	(7.7)	(12.8)	(33.8)
1985	6,811	12,069	9,744	10,937	18,746	10,796	17,313	46,021
1986	8,539	16,222	19,426	21,427	33,402	23,095	17,358	61,701
1987	6,525	11,785	14,459	18,454	22,135	18,476	15,790	73,062
1988	4,506	10,254	11,973	11,517	20,011	16,520	17,592	54,611
1989	5,241	10,198	7,846	9,160	15,410	12,787	13,069	54,264
1985-89 avg.	6,324	12,106	12,690	14,299	21,941	16,335	16,224	57,933
	(4.0)	(7.7)	(8.0)	(9.1)	(13.9)	(10.3)	(10.3)	(36.7)
1990	4,641	7,092	13,840	13,124	14,542	12,457	15,133	70,745

Table XXXVI. Deflated Value of Louisiana Shrimp Landings, by Size, 1970-90 (1980 CPI-100).

Year	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
				$ 1,000				
1970	3,859	10,498	11,654	8,506	11,019	5,101	7,962	14,220
1971	5,408	10,398	12,409	9,978	15,060	8,487	9,587	16,517
1972	4,979	12,274	11,194	7,849	15,669	8,265	9,842	21,552
1973	3,406	8,098	8,461	6,052	10,351	5,010	7,120	31,277
1974	5,001	8,385	7,126	4,201	5,649	2,564	3,367	15,080
1970-74 avg.	4,530	9,930	10,185	7,317	11,550	5,885	7,576	19,729
1975	3,900	9,702	9,328	5,705	9,011	3,682	3,401	15,481
1976	5,914	14,478	17,304	13,245	16,301	7,012	9,873	30,659
1977	3,794	12,274	12,375	10,449	18,838	8,696	15,370	34,857
1978	3,866	13,233	15,940	12,660	19,143	9,216	15,102	36,736
1979	5,888	12,270	15,345	12,182	21,529	10,964	17,101	39,315
1975-79 avg.	4,673	12,391	14,058	10,848	16,964	7,914	12,170	31,410

(continued)

Table XXXVI. Deflated Value of Louisiana Shrimp Landings, by Size, 1970-90 (1980 CPI=100).

Year	<15	15-20	21-25	26-30	31-40	41-50	51-67	>68
				$ 1,000				
1980	4,340	7,759	9,003	9,980	14,566	7,271	13,422	41,106
1981	3,873	11,867	16,533	14,567	17,854	8,941	12,248	35,115
1982	3,041	7,141	8,736	10,874	20,242	8,545	16,961	45,254
1983	3,447	7,524	7,891	8,910	17,700	9,334	14,424	37,157
1984	4,064	9,367	9,596	12,080	18,232	9,341	15,088	33,679
1980-84 avg.	3,753	8,732	10,352	11,282	17,719	8,686	14,428	38,462
1985	5,275	9,349	7,548	8,472	14,520	8,363	13,411	35,648
1986	6,416	12,188	14,595	16,099	25,096	17,351	13,041	46,357
1987	4,731	8,546	10,485	13,382	16,051	13,398	11,450	52,986
1988	3,138	7,141	8,338	8,020	13,935	11,504	12,251	38,030
1989	3,482	6,776	5,213	6,086	10,239	8,496	8,684	36,056
1985-89 avg.	4,609	8,800	9,236	10,412	15,968	11,823	11,767	41,815
1990	2,937	4,488	8,759	8,306	9,203	7,883	9,577	44,770

Source: Unpublished data provided by the National Marine Fisheries Service

Table XXXVII. Current and Deflated Value of Louisiana's Shrimp Landings by Species, 1970-90.

Year	Current Value			Deflated Value		
	Brown	White	Other	Brown	White	Other
	$1,000s					
1970	13,763	20,527	322	29,221	43,582	684
1971	17,000	26,193	91	34,553	53,238	185
1972	20,673	25,803	588	40,775	50,893	1,160
1973	17,728	25,225	1,558	32,952	46,887	2,699
1974	11,521	19,229	1,452	19,266	32,156	2,428
1970-74 avg.	16,137	23,395	802	31,353	45,351	1,431
	(40.0)[a]	(58.0)	(2.0)	---	---	---
1975	13,429	25,828	1,711	20,565	39,553	2,620
1976	31,116	48,200	344	45,030	69,754	498
1977	37,709	47,962	1,427	51,305	65,254	1,941
1978	35,756	63,760	1,136	45,204	80,607	1,436
1979	53,660	65,304	3,717	60,908	74,125	4,219
1975-79 avg.	34,334	50,211	1,667	44,602	65,859	2,143
	(39.8)	(58.2)	(1.9)	---	---	---

(continued)

Table XXXVII. Current and Deflated Value of Louisiana's Shrimp Landings by Species, 1970-90.

Year	Current Value			Deflated Value		
	Brown	White	Other	Brown	White	Other
	$1,000s					
1980	37,307	70,251	4,009	37,307	70,251	4,009
1981	50,294	83,289	2,881	45,569	75,463	2,610
1982	63,984	77,658	2,057	54,460	66,318	1,757
1983	55,552	74,651	2,185	45,949	61,746	1,807
1984	58,130	82,491	2,443	46,098	65,417	1,937
1980-84 avg.	53,053	77,668	2,715	45,877	67,839	2,424
	(39.8)	(58.2)	(3.1)	---	---	---
1985	46,483	86,017	2,541	36,005	66,628	1,968
1986	68,549	133,634	5,172	51,502	99,650	3,886
1987	78,697	102,242	3,283	57,068	74,142	2,381
1988	68,948	77,750	2,465	48,014	54,143	1,717
1989	65,087	63,108	2,058	43,240	41,926	1,367
1985-89 avg.	65,553	92,350	3,104	47,166	67,298	2,264
	(40.7)	(57.4)	(1.9)	---	---	---
1990	71,231	80,616	1,314	44,941	50,862	829
	(46.5)	(52.6)	(0.8)	---	---	---

[a] Numbers in parenthesis give the proportion of total value represented by each species during each five-year period.

Source: Unpublished data provided by National Marine Fisheries Service.

Table XXXVIII.

THIS TABLE NUMBER NOT USED.

Table XXXIX. Dockside Value of Shrimp Landed in Louisiana, by Inshore and Offshore Waters, 1976-90.

Year	Inshore State		Offshore State		Federal	
	Current Value	Deflated Value	Current Value	Deflated Value	Current Value	Deflated Value
	$1,000s					
1976	23,808	34,405	27,568	39,838	28,205	40,759
1977	27,599	37,532	33,621	45,722	25,716	34,972
1978	21,845	27,624	37,857	47,871	41,126	52,005
1979	32,106	36,502	50,444	57,352	40,131	45,626
1980	26,049	26,049	66,156	66,156	28,729	28,729
1976-80 avg.	26,281	32,422	43,129	51,388	32,781	40,418
	(25.7)	---	(42.2)	---	(32.1)	---
1981	36,449	33,093	63,350	57,516	36,666	33,290
1982	50,799	43,434	54,087	46,245	38,812	33,185
1983	43,976	36,416	53,706	44,473	34,706	28,739
1984	44,104	35,006	48,795	38,729	50,165	39,816
1985	34,897	26,723	59,560	45,610	40,582	31,077
1981-85 avg.	42,045	34,934	55,900	46,515	40,186	33,221
	(30.4)	---	(40.5)	---	(29.1)	---

(continued)

Table XXXIX. Dockside Value of Shrimp Landed in Louisiana, by Inshore and Offshore Waters, 1976-90.

Year	Inshore State		Offshore State		Federal	
	Current Value	Deflated Value	Current Value	Deflated Value	Current Value	Deflated Value
	$1,000s					
1986	59,476	44,731	89,842	67,569	57,038	42,897
1987	59,392	43,126	75,616	54,906	49,214	35,735
1988	54,215	37,801	54,983	38,336	39,965	27,865
1989	39,178	26,050	58,895	39,160	32,180	21,397
1990	49,320	31,121	84,553	53,353	19,290	12,172
1986-90 avg.	52,316 (31.8)	36,566 ---	72,778 (44.2)	50,665 ---	39,537 (24.0)	28,013 ---

Source: Compiled from unpublished data provided by the National Marine Fisheries Service.

[a] Numbers in parentheses reflect the proportion of the value of state landings represented by inshore state catch, offshore state catch, and catch in federal waters, respectively, during each five-year period.

Table XL. Comparison between Gunther's catch in 313 hours of trawling with LDWF's catch in 324 hours of trawling. Only species reported by Gunther included.

Species	Gunther	LDWF	Ratio*
Bay anchovy	29.87	55.70	1.86
Gulf menhaden	14.11	26.87	1.90
Sand seatrout	25.14	17.73	0.71
Atlantic croaker	207.36	16.01	0.08
Sea catfish	15.07	10.60	0.70
Spot	8.32	4.44	0.53
Atlantic bumper	1.10	3.53	3.20
Gafftopsail catfish	4.57	2.80	0.61
Bay whiff	2.56	2.38	0.93
Atlantic threadfish	8.73	1.77	0.20
Fringed flounder	3.81	1.65	0.43
Silver perch	4.11	1.57	0.38
Atlantic cutlass	11.58	1.50	0.13
Least puffer	0.77	1.31	1.69
Atlantic spadefish	0.71	1.10	1.54
Hogchoker	7.16	0.68	0.09
Harvestfish	0.06	0.61	10.59
Southern kingfish	4.08	0.56	0.14
Banded drum	0.56	0.56	1.02
Atlantic moonfish	8.33	0.56	0.07
Bighead searobin	0.97	0.54	0.56
Inshore lizardfish	0.05	0.48	8.74
Lined sole	1.27	0.44	0.34
Southern flounder	0.73	0.37	0.51
Star drum	30.57	0.34	0.01
Blackcheek tonguefish	1.22	0.32	0.26
Spotted seatrout	2.61	0.30	0.11
Spanish mackeral	0.07	0.23	3.45
Crevalle jack	0.15	0.10	0.62
Atlantic stingray	0.18	0.09	0.50
Gulf butterfish	4.31	0.08	0.02
Sheepshead	0.01	0.07	7.08
Lookdown	0.15	0.06	0.40
Silver seatrout	2.68	0.04	0.01
Florida pompano	0.06	0.00	0.05
Southern hake	0.36	0	0.00
Smooth puffer	0.06	0	0.00

*DWLF catch divided by Gunther catch.

Table XLI. Total and Component Value Added Per Product Pound Estimated from Survey of Gulf of Mexico Shrimp Procesors, 1987.

	S/LB		
	PUD	CANNED	BREADED
labor	.234	.333	.430
salaries	.050	.085	.033
taxes	.026	.132	.040
overhead	.072	.152	.157
rents/fees	.053	.374	.067
profit	.158	.400	.310
total	.593	1.476	1.037

Source: Roberts and Keithly (1991).

Table XLII. U.S. Imports of Shell-on Shrimp, Selected ports, by Size, Millions of Pounds, Product Weight, 1981-88.

Count	1981	1982	1983	1984	1985	1986	1987	1988
15	13.5	15.5	15.5	19.9	22.6	16.2	20.0	14.6
15-20	12.3	13.1	14.6	18.2	16.8	14.9	16.3	13.1
21-25	8.6	11.1	12.8	17.2	19.6	17.6	16.0	13.3
26-30	8.5	10.1	11.5	17.8	22.4	21.2	18.0	17.9
31-40	12.6	15.1	17.4	26.1	30.1	31.3	33.2	37.0
41-50	6.1	9.2	9.9	13.8	16.1	18.1	21.3	30.8
51-60	3.2	5.0	5.8	8.7	10.0	10.1	12.4	16.8
61-70	2.8	3.9	3.9	5.9	7.5	6.4	10.2	9.3
71+	3.6	4.3	6.1	10.9	10.3	10.1	14.7	10.1
pieces	1.8	2.3	3.4	4.1	6.0	6.3	5.2	4.6
unclas	51.0	62.5	73.5	38.3	11.5	11.3	12.6	13.5
Total	124.0	152.1	174.5	180.8	172.7	163.4	179.9	180.3

Source: Roberts and Keithly (1991).

Note: Totals may not add to 100, due to rounding.

Table XLIII. U.S. Imports of Peeled Shrimp, Selected Ports, by Size, Millions of Pounds, Product Weight, 1981-88.

Count	1981	1982	1983	1984	1985	1986	1987	1988
15	.7	.9	.9	1.0	.8	.5	1.9	.6
15-20	1.7	1.5	1.3	1.4	1.1	1.4	2.7	1.8
21-25	1.5	1.4	1.6	2.1	1.7	2.2	4.6	2.3
26-30	1.9	1.5	2.0	2.6	2.5	2.6	5.3	3.2
31-40	2.5	1.9	2.7	3.7	4.2	3.0	8.8	6.2
41-50	1.2	1.1	1.8	2.2	2.6	1.7	4.3	3.9
51-60	.6	.8	1.5	1.5	1.9	1.6	3.3	3.1
61-70	.5	.6	1.3	1.6	1.6	2.1	2.6	3.0
71+	13.1	29.0	44.1	36.7	42.7	43.1	37.7	32.5
pieces	2.6	2.3	4.0	3.7	4.3	4.5	2.0	1.3
unclas.	18.9	13.4	10.1	3.8	4.1	10.6	7.6	3.1
Total	45.4	54.5	71.2	60.3	67.6	73.2	80.7	60.9

Source: Roberts and Keithly (1991).

Note: Totals may not add to 100, due to rounding.

Appendix A - History of Louisiana's Shrimp Laws

Introduction

What follows is a chronological history of Louisiana's shrimp laws, plus some relevant other statutes. This history was compiled by reviewing Louisiana statute books from 1807 (the earliest volume available) through 1991 in the Hebert Law Center Library at Louisiana State University.

Until 1950, when Louisiana statutes were codified, Louisiana statutes generally referenced themselves as amendments to prior acts of previous years. However, since 1950, when Louisiana wildlife and fisheries laws were codified as Title 56 of the Revised Statutes, newer acts have referred to "sections" of Title 56 that are being amended or added.

It is interesting to note that the 3 topics most often addressed in these statutes are the delineation of the inside-outside shrimp line, the dates for seasons, and the regulation or prohibition of certain types of gear. The difficulty in "legislating" these 3 topics, and perhaps other shrimp matters, could indicate that these topics are better left to Wildlife and Fisheries Commission regulation, subject to legislative oversight of the Commission, as is now the case in setting shrimp seasons.

While the current structure for management of the Louisiana shrimp fishery is for administrative matters to be the responsibility of the Department and for policy matters and necessary regulations to be the responsibility of the Commission, this structure, as the chronology shows, has had a very complex development.

Chronological History of Shrimp Legislation in Louisiana

1886 - Act 106. All state owned waterbottoms may be used as a commons by all the people of the state for the purpose of catching oysters and other shellfish. (emphasis added).

1904 - Act 85. Established the basket as the standard measure for weighing shrimp, a basket containing seventy pounds of shrimp.

1908 - Act 144. Established a Commission for the Conservation of Natural Resources, composed of seven members, to study natural resources of the state and recommend what legislation for the

conservation of natural resources would be advisable.

1910 - Act 172. Created an eight member Conservation Commission to regulate natural resources in Louisiana who were to designate a Chairman from among their members. 3 members were ex-officio state officials and 5 were to be appointed by the Governor.

1910 - Act 245. First comprehensive statute for shrimp. Illegal to catch shrimp using a seine in excess of 120 fathoms, except as provided in this statute. Illegal to draw a seine or other devices 50 fathoms in length or longer without paying a license fee. Established a license on shrimp seines: seines 200-1,000 feet in length, $10 residents, $50 nonresidents; on seines over 175 fathoms in length, an additional license of $1 for each twenty fathoms for residents, $5 for each twenty fathoms for non-residents. Established a closed season from June 1-July 14. Empowered the Board of Commissioners for the Protection of Birds, Game, and Fish to issue regulations for shrimping. Required seines to be tagged with an official license tag. Made it illegal to seine for shrimp in the waters of the state "from a boat provided with such means of propulsion as steam, gasoline, electricity, compressed air, or any power or device other than oars or sails."

1912 - Act 127. Established a Conservation Commission, composed of 3 Commissioners appointed by the Governor; and specifically put shellfish, including shrimp, under its regulation. The Commissioners were to be people informed, "in whole or in part" (sic), on wildlife, game, and the requirements for its conservation; oysters and salt and fresh water fish of the state; and the forestry and mineral resources of the state. Empowered the Commission to issue regulations for the comprehensive control of shellfish. Created a Conservation Fund and provided that all funds collected by the Conservation Commission shall be paid into the State Treasury for the benefit of the Conservation Fund. This Commission superseded the Board of Commissioners of Birds, Game, and Fish and the Oyster Commission.

1912 - Act 168. Comprehensive shrimp regulation statute that amended Act 245 of 1910. Illegal to catch shrimp using a seine longer than 60 fathoms except as provided therein. Set 2 closed shrimp seasons, Dec. 1 - Feb. 1 and June 1 - July 1. Added a minimum mesh size for shrimp seines of three-quarters of an inch square. Increased seine license fees. Allowed for the catching of salt water fish or crustaceans in a shrimp seine while shrimping, without obtaining an additional license therefor.

1914 - Act 45. It is the duty of Conservation Agents to see that every person seining, shipping or dealing in any way in any of the natural resources of the state in the territory assigned to an Agent has the proper license in possession.

1914 - Act 59. Comprehensive shrimp regulation statute. Illegal to catch shrimp using a seine longer than 40 fathoms except as provided therein. Set 2 closed shrimp seasons, Dec. 1 - Feb. 15 and June 1 - July 15. Increased seine license fee. Licenses must be in possession at all times.

1916 - Act 66. Creates the Department of Conservation, directed and controlled by an official known as Commissioner of Conservation, appointed by the Governor, who should be "informed", in whole or in part, on the subject of the wildlife, game, and fish and the requirements for their conservation, oysters, salt and fresh water fish of the state, and the forestry and mineral resources of the state. There shall not be any attorney other than the Attorney General paid to represent the Department.

1916 - Act 193. Repealed the prohibition on the use of a machine-powered boat for catching shrimp.

1918 - Act 86. All salt water shrimp found in the waters of the state are declared to be the property of the state. First mention of inside and outside waters, which are not defined. First regulation of trawls, a prohibition on the use of trawls in any of the inside waters of the state when doing so is determined by the Department of Conservation to be detrimental to the interests of the state. Allows the catching of shrimp for canning or drying

purposes in closed season by trawls from any of the outside waters of the state with a permit and license from the Department, provided said shrimp do not measure less than 4 inches in length. Unlawful to sell shrimp during closed season except that shrimp four inches long or longer caught in outside waters can be sold.

1918 - Act 105. Reaffirms Department of Conservation and Department of Conservation control over shellfish. Empowers the Commissioner to appoint Conservation Agents. Gives Department extensive search authority upon good cause to believe there has been a violation of the law.

1920 - Act 68. Specifies that the control of shrimp industry is vested in the Department of Conservation, which may issue rules and regulations concerning shrimp fishing. The first delineation of what constitutes inside and outside waters is set forth. Makes it illegal to pack, can, or dry shrimp caught in the Gulf of Mexico outside the 3 mile limit during closed season. Bait shrimp allowed to be taken at any time. Unlawful to take shrimp from Louisiana waters for sale or drying or canning that measure less than 4 inches in length from the "tip of the spear of rostrum to the end of tail fan". Specifically provides for a shrimp trawl license for the first time. Licensed persons allowed to catch, dry and can "six barbe" during the closed season and open season. Allows the Department of Conservation to prohibit the use of trawls in inside waters when the Department finds that such usage is detrimental to the interests of the state. License fees turned into the state treasury and placed to the credit of the Department. Department authorized to fix license fees for devices other than seines or trawls. First severance tax on shrimp set forth. Established licenses for shrimp canning or packing plants and drying platforms. Allows for shrimping gear to be confiscated.

1924 - Act 69. Prohibits the drying of fish on shrimp or fish drying platforms during the months May-July.

1924 - Act 140. Comprehensive shrimp statute. All saltwater shrimp found in Louisiana waters are declared

the property of the state. Delineates inside and outside waters. Specifies 2 closed seasons, Dec. 1 - March 1 and June 15 - August 15. Increases shrimp severance tax. Illegal to use a shrimp seine in excess of 10 fathoms, a trawl, or other device without a license.

1924 - Act 224. Requires the Conservation Commission to prepare an annual report, including such recommendations for legislation as it deems wise.

1926 - Act 103. Declared that all salt water shrimp existing in the waters of the state and the hulls and parts thereof are property of the state. The control of the shrimp industry is specifically vested in the Department of Conservation. Inside-outside waters delineated. Made it unlawful for any nonresident to catch salt water shrimp in the waters of this state or to can, pack, or dry in any factory or platform in this state any shrimp taken from the waters of this state. Closed season, all waters, June 15-Aug. 15. Inside closed seasons Dec. 1-March 15 and June 15-Aug. 15. Can't take shrimp less than 4 inches long from the "tip of the spear or rostrum to the end of tail fin" - this restriction does not apply to shrimp taken for bait nor to "sea bobs" or "sea barbes". License and severance tax provisions. Unlawful to ship shrimp shells, heads, and hulls outside the state. All licensees shall conserve for fertilizer purposes all shells or bulls and heads of shrimp for fertilizer purposes. These provisions shall be broadly construed. Seines 10 fathoms in length may be used for catching shrimp without a license. If devices other than seines or trawls are used in catching shrimp, the Department can fix a license fee in accord with seine and trawl license fees.

1926 - Act 235. Reaffirms prohibition of drying fish on shrimp platforms of Act 69 of 1924.

1932 - Act 50. Comprehensive shrimp regulation statute. New delineation of inside-outside shrimp line. 2 closed seasons established, March 1 - April 15th and June 10th - August 10th. Illegal to use a seine longer than 5 fathoms or a trawl without a license as provided herein. Increases severance tax. Canning factories,

packing plants, drying platforms and wholesale dealers must keep records of their shrimp transactions in the English language.

1932 - Act 134. Department of Conservation empowered to collect severance taxes on shrimp fished from Louisiana waters and sent out of state and to establish tax-paying depots for collecting the tax.

1932 - Act 206. Exempts contracts or agreements for seafood, including shrimp, from antitrust violations.

1934 - Act 193. First requirement of a license for shrimp wholesalers and retailers. Prohibited the use in Louisiana waters for shrimping of seines in excess of 3,000 feet in length and trawls with a spread of more than 100 feet. No vessel allowed to operate more than one trawl at a time.

1940 - Act 10. New delineation of inside-outside line. Makes it a misdemeanor for any person, firm, corporation to use or have in possession any trawl in excess of 60 feet in length for the purpose of catching shrimp. Illegal for nonresidents to catch shrimp in the waters of the state or to can, pack, or dry in any factory or platform in this state any shrimp caught from the waters of this state. Non-resident catching boats, freight boats and ice boats must obtain a license from the Conservation Commission for $2,000. If more than 50 pounds of shrimp is found aboard an out-of-state boat in state waters, this is prima facie evidence that the shrimp were illegally taken in state waters. Canning factories, packing plants, drying platforms, and wholesale dealers shall keep their business records for 3 years. Establishes 2 closed seasons, March 1 - April 15 and June 10 - August 10. Provides for shrimp licensing reciprocity agreements with other states.

1940 - Act 314. Redefines inside-outside shrimp line. Establishes a $5 license fee for all resident freight and ice boats carrying shrimp from Louisiana waters for sale in the fresh state, or for canning, packing and drying in Louisiana. Other provisions are similar to those in Act 10 of 1940.

1940 - Act 408. A concurrent resolution to authorize and request the Department of Conservation to establish a line between salt water and fresh water.

1942 - Act 80. Unlawful to take or to have in possession any salt water shrimp less than 4 inches in length.

1942 - Act 143. Defines several terms used in shrimp statutes, including "salt water shrimp", "length of seines, trawls, or other netting", and "size of the mesh". Vests the "exclusive control" of the shrimp fishery and the shrimp industry in Louisiana in the Department of Conservation. Redefines the inside-outside shrimp line. Sets 2 closed seasons for inside waters, March 16th - May 15th and June 26 - August 15. The restrictions prohibiting nonresidents from taking or processing shrimp in the state does not apply to citizens of any state having a reciprocity agreement with Louisiana. Fishermen can secure shrimp for bait during closed seasons, provided they do not take or have in possession shrimp taken in closed waters in quantities over 105 pounds, or half a barrel. Saltwater shrimp can't be caught in trawls or seines in inside waters between the hours of sunset and sunrise. First shrimp count law, 68 shrimp to the pound. The count law does not apply to shrimp taken or possessed for bait, to "Brazilian" or "grooved shrimp" when taken between May 16th and June 25th, nor to "sea bobs" taken at any time. License fees due on the first day of January each year. Shipments of shrimp made to points outside the state must be registered at some port of exit established by the Department and certificates of export must be obtained before such shrimp can be legally transported out of state. Vessels and equipment used in illegal taking or transporting shrimp may be confiscated by the Department.

1942 - Act 145. Comprehensive fisheries management statute. "Fish" is defined to include "shellfish".

1944 - Act 328. Proposed constitutional amendment creating a Department of Wildlife and Fisheries and a Department of Conservation out of the former Department of Conservation. Passed by voters.

1946 - Act 78. Comprehensive shrimp regulation statute. Among other provisions, it places exclusive control of the shrimp fishery and shrimp industry in Louisiana in the Louisiana Department of Wildlife and Fisheries. Establishes a closed season for inside waters of December 15 - March 15 and a closed season for inside and outside waters of June 10 - the second Monday in August of each year. Exempts from the 68 count size limit established by Act 143 of 1942 "Brasilian" (sic) or "grooved shrimp" when taken between May 1 - June 11 of the same calendar year and "sea bobs" taken any time in open season. Established a seine license schedule based on the length of the seine in "feet", not fathoms. Sets a $10 fee for each trawl in operation. Establishes first shrimp vessel license, based on length of the vessel. All vessels having this vessel license shall be deemed to be shrimping solely in Louisiana waters and all shrimp caught or transported by such a vessel shall be deemed to have been taken in Louisiana waters and subject to the severance tax. If necessary for severance tax collection for shrimp transported out of state, a port of exit can be established beyond the boundary of the state. Vessels owned by residents of a state that has entered into a reciprocal agreement with Louisiana may be licensed by Louisiana to engage in shrimping or freighting operations in a specifically delineated zone that generally consists of Louisiana waters east of the East Pearl River and the Mississippi River. First license requirement for shrimp wholesalers' agents and for shrimp retailers. Shrimp severance taxes are computed on shrimp in the fresh state as of delivery to the first purchaser and shall be paid by him. Vessels, airplanes, or other forms of transport used in the illegal taking or transportation of shrimp can be seized. For purposes of this Act, the jurisdiction of the courts of any parish shall extend to the limits of the state's sovereignty over tidal waters and the bottoms thereof. The Act contains other provisions governing legal proceedings engaged in by the Department.

1946 - Act 196. Comprehensive <u>fisheries</u> regulation statute. "Fish" defined to include shellfish.

1946 - Act 210. Prohibits non-resident commercial fishermen from catching or taking any shrimp or operating a fishing boat for shrimping from Louisiana tidal salt waters known as "restricted tidal waters" and defined herein. Illegal for non-resident commercial fishermen to catch shrimp in other than "restricted tidal waters" of the state unless a $200 non-resident commercial fisherman's license and a $2,500 non-resident commercial fishing boat license have been obtained.

1948 - Act 36. To create a Director of Commercial Fisheries and Trapping, appointed by the Governor. Gives the Director regulatory authority over shrimp.

1948 - Act 51. Defines inside and outside waters for shrimping. Establishes a 68-count size limit for shrimp, which doesn't apply to shrimp taken for bait. The count law doesn't apply to "Brazilian" or "grooved shrimp" when taken between April 15 and June 21st but does apply to them from the second Monday in August to May 1. Establishes 2 closed seasons for inside waters, February 15 - April 15 and June 21 - the second Monday in August of each year.

1948 - Act 329. Adopts the Gulf States Marine Fisheries Commission interstate compact.

1948 - Act 385. Comprehensive fisheries regulation statute. "Fish" defined to include "crustacea".

1948 - Act 386. Comprehensive fisheries regulation statute. "Fish" includes "shellfish". Establishes Division of Commercial Fisheries and a Commissioner of Commercial Fisheries and Trapping with regulatory authority over shrimp.

1950 - Act 544. Comprehensive shrimp regulation statute. Defines minimum mesh size for shrimp seines, trawls, or other devices as three-fourths of an inch "bar" or one and one-half of an inch stretched, except for taking bait. Repeats count law provisions of Act 51 of 1948. Severance tax increased.

1952 - Act 57. Proposed Constitutional amendment to establish a Louisiana Wildlife and Fisheries Commission of 7 members, directed by a Commissioner, to

have general control and management of the Commission. The functions of the Louisiana Department of Wildlife and Fisheries and the Commissioner of Wildlife and Fisheries are transferred to the Commission. Functions of Commissioner are to be administered under the guidance of the Commission. Passed by voters.

1952 - Act 267. Sets license fees for shrimp seines and trawls based on length and for shrimp vessels, based on length.

1952 - Act 627. Establishes license fees for shrimp seines and trawls, based on length, and shrimp vessel license fees, based on length. Establishes gear and vessel licenses. A boat licensed for commercial fishing may engage in shrimping without an additional license.

1954 - Act 251. Sets size limits for shrimp trawls used in Vermilion Bay and East and West Cote Blanche Bays.

1954 - Act 348. Sets two shrimp seasons for inside waters. Exempts bait shrimp fishermen from closed season restrictions. No shrimp can be caught in trawls or seines in inside waters between sunset and sunrise. Any vessel not tied up in port during these 2 closed seasons in inside waters, can have in possession on board a trawl longer than 16 feet unless the vessel is in the actual process of moving into outside or open waters.

1954 - Act 476. Established a sanctuary from shrimping in Lake Catherine and a portion of Lake Pontchartrain.

1954 - Act 595. Sets two shrimp seasons for inside waters. (?)

1956 - Act 92. Extensive delineation of inside-outside water "line" for shrimping.

1956 - Act 352. Permitted trawling for bait shrimp in the portion of Lake Pontchartrain made a sanctuary by Act 476 of 1954.

1958 - Act 53. Comprehensive shrimp regulation statute. Defines several terms used in the shrimp statutes, including "salt water shrimp". Defines the inside-outside shrimp line. Makes it illegal for a boat to use 2 or more trawls

at the same time in inside waters. No trawl greater than 50 feet can be used in inside waters, and no trawl shall be used in closed waters. Established a sport shrimper license. Established 2 seasons in inside waters, December 21 - April 30 and July 1 to the third Monday in August of each year. Established a count-size law of an "average" of 68 shrimp to the pound, except during the open season from May 1st to June 30th, when there is no count restriction and from November 15th - December 20th, when there shall be no count limitation on the brown, or Brazilian type shrimp. There is no count restriction on "sea bobs" or for shrimp taken legally for bait. Contains shrimp gear and vessel license fees. Numerous provisions with respect to judicial proceedings for violations of shrimp statutes.

1960 - Act 160. Establishes the Department of Wildlife and Fisheries, the office of Commissioner of Wildlife and Fisheries and the Louisiana Wildlife and Fisheries Commission.

1960 - Act 515. Establishes Lake Catherine and a portion of Lake Pontchartrain as a sanctuary from shrimping.

1962 - Act 452. Extensively delineates inside-outside line and appends a descriptive map. Establishes a spring open season in inside waters, opening no earlier than May 1 and no later than May 15 at the discretion of the Wildlife and Fisheries Commission and extend for a 60 day period. Establishes a fall open season in inside waters from the 3rd Monday in August - December 21. No closed season in outside waters. Count-size limit of 68 shrimp to the pound, except during the spring inside waters open season, and from November 15 to December 20th where there is no restriction on count for brown, or Brazilian shrimp. There is no count law for "sea bobs" or "six barbes", or for legally taken bait shrimp.

1964 - Act 490. Trawling in inside waters not allowed during the closed season. Specifies legal gear for bait shrimping. No vessel may trawl for shrimp with more than 2 trawls and no trawl over 50 feet long can be used in inside waters.

1966 - Act 54. Changes statutory dates for spring open season in inside waters. The spring season commences not earlier than May 1 nor later than May 25 at the discretion of the Commission and extends for a period of not less than 50 nor more than 60 consecutive days thereafter.

1966 - Act 99. Authorizes and requests the Louisiana Wildlife and Fisheries Commission to clear the debris and obstruction caused by Hurricane Betsy in Louisiana's shrimping waters.

1966 - Act 190. No person shall use a trawl for taking shrimp at night in Calcasieu Lake. Butterfly nets may be used night and day in Calcasieu Lake, Calcasieu River, and Calcasieu Ship Channel in Cameron Parish during open season.

1966 - Act 421. First regulation of beam trawls and butterfly nets used in shrimping. Minimum mesh size for these 2 types of nets is five-eights of an inch "bar" and one and one-fourths inch stretched. Use of beam trawl and butterfly nets shall "in no way" impede normal navigation. Each such net must be equipped with not less than 2 navigation lights when used one-half hour after sunset to one-half hour before sunrise.

1968 - Act 53. Specifies gear that may be used for catching bait shrimp.

1969 - Act 60. Open seasons for all <u>or part</u> of the inside waters may be set by the Commission, including the right to open or close seasons from time to time other than during the regular seasons. Opening of the season shall be based on the best technical data presented to the Commission that marketable shrimp are available. Seasons can be opened or closed at regular meetings of the Commission or at a special meeting, with 7 days notice. The Commission is to fix no less than 2 open seasons for all inside waters. One of these seasons is to commence not later than May 25 and remain open a minimum of 50 days or until technical data indicates a need for closure to protect the forthcoming white shrimp, and the other season is to begin on the third Monday in August and remain open until December 21. No open season is to begin on a Sunday.

1971 - Act 179. During the open season in inside waters, no vessel rigged for double trawls, nor any "Biloxi type" vessel, single or double rigged, shall trawl in inside waters, except within Breton Sound and Chandeleur Sound, where they may trawl up to the outermost points of the main land mass in open season.

1971 - Act 504. Specifies the gear that can be used for bait shrimping . No shrimp can be taken in inside waters using a butterfly net, paupier, trawl, night trawl, or beam trawl except as otherwise provided by statute.

1972 - Act 203. First delineation of the inside-outside line by coordinates.

197 - Act 772. Constitutional amendment to exempt commercial diesel-powered shrimp boats from the ad valorem tax. Passed by voters.

1974 Article IX §6 of the Louisiana Constitution. Established the Louisiana Wildlife and Fisheries Commission as a constitutional agency.

1974 - Act 14. Establishes a loan guarantee program for shrimp fishermen, the Commercial Shrimp Fisherman Loan Guaranty Security Fund. $5 million is appropriated to the fund, and the maximum loan guarantee per shrimper is $5,000. Find the Fund necessary because the commercial shrimp industry is on the verge of destruction due to the devastating effect of natural catastrophe on the shrimp resource and equipment of shrimpers and the crippling affect of the worldwide energy crisis on the operating costs and market prices applicable to these fishermen. No new applications for loan guarantees are to be accepted after July 1, 1975.

1974 - Act 490. Wildlife and Fisheries Commission given the authority to set special shrimp seasons for all or part of the inside waters, in addition to the Commission's other authority to set seasons.

1974 - Act 717. Redesignates the section numbers of the wildlife and fisheries statutes. Changes the Department of Wildlife and Fisheries to the Wildlife and Fisheries Commission and the

position of the "Commissioner" of Wildlife and Fisheries to "Director" of the Wildlife and Fisheries Commission. Sets forth the powers of the Commission.

1974 — Article IX, Section 1, of the 1974 Constitution makes the Louisiana Wildlife and Fisheries Commission a Constitutional agency.

1975 - Act 245. — Bait seines longer than 30 feet but not exceeding 100 feet in length can be used for taking only south of the saltwater-freshwater line, as delineated by statute.

1975 - Act 819. — Reestablishes the Commercial Shrimp Fishermen Loan Guarantee Security Fund and reallocates the $5 million to the Fund.

1976 - Act 238. — Commission empowered to adopt rules and regulations for a bait shrimp dealer's permit and to allow for the taking of live shrimp by permit holders during the closed season between the spring and fall shrimp seasons.

1977 - Act 83. — Creates the Department of Wildlife and Fisheries and places the Wildlife and Fisheries Commission in the Department.

1977 - Act 127. — Delineates inside-outside shrimp line.

1977 - Act 549. — No shrimp vessel, during the open season, pulling 2 trawls, nor any Biloxi type vessel, single or double rig, can trawl in inside waters - except within Breton Sound and Chandeleur Sound, in which sounds they may trawl up to the outermost point of the land mass in open season. Provides for penalties.

1978 - Act 295. — Defines the terms "double rigged" and "double trawls" for purposes of the prohibition on trawling in inside waters. "Double rigged" or "double trawls" is defined as two trawls, each trawl being fifty feet or less in length along the cork line.

1979 - Act 284. — Comprehensive shrimp regulation statute. Commercial shrimp vessels may use a test trawl not exceeding sixteen feet without additional license provided that a license fee has been paid on one or more larger trawls. A sports fisherman may use a trawl not to exceed 16 feet in open waters in open season without

payment of license. Sports shrimpers daily limitation is 100 pounds in the aggregate at any one time per day to each boat irrespective of the number of persons thereon. The holder of a commercial shrimp seine or trawl license may sell, in addition to legal size shrimp, any legal size fish or crustaceans caught in his shrimp seine or trawl and the holder of a trawl license may sell fish taken with pole or line or cast net without the payment of additional licenses. Any person selling his catch is considered a commercial fisherman and must have the necessary licenses. No vessel shall be used to transport shrimp taken in Louisiana waters to points out of state unless severance taxes have been paid thereon - or due arrangement has been made for payment with the Commission - at the port of exit designated by statute.

1979 - Act 286. Shrimp trawl must have a mesh size of at least three-fourths of an inch bar or one and one-half inch stretched. A beam trawl or butterfly net must have a mesh size of at least five-eighths of an inch bar or one and one-fourth inch stretched. No trawl, beam trawl, or butterfly net can be used in closed waters. A bait seine is the only seine that can be used in closed waters. No shrimper can use a double beam trawl or butterfly net with individual nets measuring more than 12 feet horizontally or vertically each, or a single beam trawl or butterfly net greater than 22 feet horizontally or vertically. Operation of beam trawls and butterfly nets cannot impede or restrict normal navigation.

1979 - Act 291. No vessel can pull more than one trawl, which cannot exceed 50 feet, in inside waters except that each vessel may, in addition to one trawl, pull a test trawl. No vessel can pull more than 2 trawls of 50 feet each, plus a test trawl, in Breton and Chandeleur Sound. "Test trawl" means a trawl not longer than 16 feet, which is exempted from licensing. No vessel can pull more than 2 trawls and one test trawl in outside waters.

1979 - Act 458. Provides that the total of outstanding loans made pursuant to the Commercial Shrimp Fisherman Loan Guarantee Fund, shall not exceed $500,000 at any time.

1979 - Act 673. Establishes the Fisherman's Gear Compensation Fund.

1980 - Act 817. During the May shrimp season, no one can use a trawl for catching shrimp that has a mesh size of less than five-eighths of an inch bar or one and one-fourth inch stretched.

1980 - Act 834. Established Commercial Fisherman's Fuel Compensation Fund.

1981 - Act 157. Establishes a preference program for governmental entities in Louisiana for purchases of Louisiana products, when the cost of a Louisiana product does not exceed the cost of an out of state product by more than 5%. To come under this preference, shrimp must be harvested in Louisiana seas (sic) or other waters or harvested by a person who holds a valid appropriate commercial license from the Department of Wildlife and Fisheries.

1981 - Act 492. Louisiana commercial shrimping licenses, both resident and non-resident, shall be obtained from the Department of Wildlife and Fisheries during the one-month period from January 1 through February 1 of each calendar year. Sets resident and non-resident license fees. License for a newly acquired vessel obtained at a time other than January 1 - February 1, the appropriate licenses can be acquired within 45 days after acquisition of the vessel.

1981 - Act 890. Established the Louisiana Seafood Promotion and Marketing Board.

1982 - Act 405. The term "shellfish" used in Louisiana fisheries statutes is defined to specifically include shrimp.

1982 - Act 729. The term "beam trawl" used in Louisiana shrimp statutes is defined.

1982 - Act 777. Decreases the minimum mesh size for shrimp trawls from three-fourths of an inch bar and one and one-half inches stretched to five-eighths of an inch bar and one and one-half inch stretched.

1983 - Act 515. No resident nor non-resident shall possess shrimp on board any boat or vessel in

Louisiana waters for commercial purposes unless the required commercial shrimp licenses have been obtained and are on the vessel or boat.

1984 - Act 120. When a decision to open or close a shrimp season has been made by the Commission, the decision won't take effect for at least 72 hours after notice to the public.

1984 - Act 230. Increase commercial fishing licenses, including shrimping licenses, by $5 each to fund the Seafood Promotion and Marketing Fund established by this Act. Funds the Louisiana Seafood Promotion and Marketing Board.

1984 - Act 255. A person on a vessel can use a double beam trawl or butterfly net having individual nets measuring not greater than 16 feet horizontally or 12 feet vertically, each. No one can use "sweeper" devices, leads, or other extensions in conjunction with or attached to beam trawls or butterfly nets.

1984 - Act 295. Comprehensive fisheries management statute. Repealed the license fee for shrimp seines. A holder of a shrimp trawl license wishing to sell finfish must possess a resident or non-resident seller's license.

1984 - Act 299. Shrimp licenses for resident commercial shrimpers can be obtained from the Department of Wildlife and Fisheries throughout the year. Non-resident commercial shrimper's licenses must be obtained from the Department during the one-month period January 1 - February 1. However, for the introduction of a newly acquired vessel into the commercial shrimping fleet at a time other than January 1 - February 1, the appropriate licenses can be obtained within 45 days after acquisition of the vessel.

1984 - Act 300. The shrimping season in outside waters is closed from January 15 - March 15, allowing for a 15-day leeway on the opening and closing as determined to be appropriate by the Commission. The Commission must give 72-hours notice prior to exercising this 15-day leeway.

1984 - Act 586. During the spring open shrimp season, there is no count limitation on any salt water shrimp

taken or held in possession. From November 15 - December 20, there is no count limitation on brown, or Brazilian-type shrimp. The possession count on white shrimp taken in inside or outside waters must average no more than 100 specimens to the pound. This count applies to the taking or possession of white shrimp aboard a vessel or at the dock or to the possession of such shrimp by the first buyer. This count restriction does not apply to "sea bobs" or "six barbes", which can be taken or sold through commercial channels in any season only in outside waters. There is no count restriction on bait shrimp legally taken.

1984 - Act 628. Shrimp licenses for residents and nonresidents may be obtained from the Department of Wildlife and Fisheries throughout each month of the calendar year (emphasis added).

1984 - Act 692. Comprehensive shrimp regulation statute. Exclusive control and supervision of the shrimp industry is vested in the Louisiana Wildlife and Fisheries Commission. However, the Department is to enforce the laws, rules, and regulations, regulating the shrimp industry in both inside and outside waters. No trawling is permitted in state waters during the closed season. A vessel can pull no more than one trawl in inside waters, which shall not exceed 50 feet in length, except that in addition to one shrimp trawl a vessel may pull a test trawl. Outside waters may be closed by the Commission for a period not to exceed 60 days, during the period January 15 - March 15 on the west bank of the Mississippi River and from February 15 - April 15 on the east bank of the Mississippi River, allowing for a 15 day leeway on the opening and closing as determined by the best biological data available to the Commission, with 72-hour notice prior to exercising this leeway. No shrimp may be taken in state waters during closed seasons with the use of a butterfly net, paupier, trawl, night trawl or beam trawl except as provided in the shrimp statutes.

1984 - Act 693. The use of a "chopstick beam trawl" for commercial shrimping shall be prohibited in inside and outside waters. "Chopstick beam trawl" is defined herein. Increases license

fees for beam trawls and butterfly nets.

1985 - Act 872. Deleted redundant provision prohibiting the use of a shrimp trawl longer than 50 feet in length in Vermilion Bay, East Cote Blanche Bay, and West Cote Blanche Bay. Use of a shrimp trawl for taking shrimp at night in Calcasieu lake is prohibited. Butterfly nets can be used for taking shrimp in Calcasieu Lake, Calcasieu River, and Calcasieu Ship Channel, all in Cameron Parish, in daytime and nighttime, during open season.

1985 - Act 876. Comprehensive fisheries law amendment statute. Vests the exclusive control of shrimp the fishery and shrimp industry in the Department of Wildlife and Fisheries, which is charged with enforcing the shrimp laws. Repeals some shrimp statutes.

1985 - Act 908. Redefines shrimp "trawl". Shrimp can be taken by means of trawls, butterfly nets or cast nets and by no other means except as otherwise provided by statute, including licensed experimental gear. No trawl or butterfly net shall be used in closed waters. No one can use for shrimping a single stationary butterfly net having an individual net frame greater than twenty-two feet measured horizontally or vertically, whichever distance is greater.

1985 - Act 918. No one can use a trawl for taking shrimp at night in Calcasieu Lake, the Black Bayou System or Little Burton's Ditch.

1986 - Act 397. Specifies conditions put on butterfly nets for shrimping in West or East Pass of Oyster Bayou or Oyster Bayou.

1986 - Act 494. Allows the Department and Commission to use the emergency provisions of the Louisiana Administrative Procedures Act in setting shrimp seasons by exempting the setting of the shrimp seasons from prior legislative oversight.

1986 - Act 554. Defines the inside-outside shrimp line.

1986 - Act 570. Provides that the shrimping season in outside waters can be closed by the Commission from January 15 - April 15, for such period of time

deemed appropriate by the Commission.

1986 - Act 988. The Louisiana Right to Fish Law. Delineates procedure to be followed by the Department and the Legislature in order to eliminate a presently legal method to harvest fish.

1986 - Act 1077. Prohibits use of a shrimp trawl for taking shrimp at night in the Cameron Parish sections of Calcasieu Lake, Calcasieu River, and Little Burton's Ditch. Sets forth restrictions on the use of butterfly nets in East and West Passes of the Calcasieu River, in Grand Bayou, and in Oyster Bayou, all within Cameron Parish only.

1986 Act 24 of the First Extraordinary Session. Returns the balance of Funds in the Commercial Shrimp Fisherman Loan Guaranty Security Fund on July 1, 1986 and all funds subsequently placed in the Fund during the 1986-87 fiscal year to the general fund.

1987 - Act 283. The Department of Wildlife and Fisheries is prohibited from enforcing any federal law or regulations requiring commercial or recreational shrimp fishermen in Louisiana to use TEDS until specified conditions have been satisfied.

1987 - Act 517. In the Rigolets and in those portions of Lake Pontchartrain and Lake Borgne within 2 miles of the Rigolets, a butterfly net or bottom net may be used to catch shrimp only when suspended from a fishing boat or vessel that is motor-propelled and underway. Neither a butterfly net nor a bottom net can be suspended from a piling, float, barge, raft, bridge, or shore installation in the Rigolets or in those portions of Lake Pontchartrain or Lake Borgne within 2 miles of the Rigolets.

1987 - Act 576. The Commission retains and can exercise the authority to open outside waters to shrimping between January 1 and May 1 each year as it deems appropriate upon inspection of technical and biological data. The shrimp season is to be closed on January 15 for such a period deemed appropriate by the Commission. Unless biological evidence indicates otherwise, the shrimping season in waters which extend due south of Zone III to the 3 mile limit can be

opened by the Commission on or between March 15 - April 1 and the shrimping season in waters which extend due south of Zones I and II to the 3 mile limit may be opened by the Commission on or between April 15 - May 1.

1987 - Act 876. Defines the inside-outside line.

1988 - Act 620. Adds Chef Menteur Pass and those portions of Lake Pontchartrain or Lake Borgne which are within 2 miles to those areas of Act 517 of 1987 in which the use of a butterfly net or bottom net for shrimping is restricted. However, in Chef Menteur Pass, a properly licensed single butterfly net measuring not more than 22 feet by 22 feet can be suspended from a wharf which has been approved by the U.S. Corps of Engineers and is attached to privately owned or leased immovable property, provided that the owner or lease holder is present on the property at all times that the net is in the water.

1988 - Act 893. Deletes statutory shrimp season "dates". Empowers the Commission to retain and exercise the authority to close outside waters by zone each year as it deems appropriate upon inspection of technical and biological data. The Commission is given authority to fix no less than 2 open seasons each year for all inside waters by zone, based on biological and technical data. The Commission must give 72 hour notice prior to opening or closing shrimp seasons.

1988 - Act 894. Defines the inside-outside line.

1988 - Act 959. Allows for seizure of shrimp taken in closed season.

1988 - Act 983. Gives the Wildlife and Fisheries Commission the authority to open and close season in inside and outside waters based on biological and technical data.

1989 - Act 85. Amends the count law provisions for white shrimp. When more than 50% of a shrimp catch by weight is sea bobs, then a maximum allowable by-catch of undersized white shrimp is permitted in an amount not to exceed 10% by weight of the total catch.

1989 - Act 489. Amends the provisions of the count law for white shrimp. When more than 50% by weight of the saltwater shrimp taken or possessed is sea bobs, then the maximum allowable amount of undersized white shrimp taken or possessed can not exceed 10% by weight of the total saltwater shrimp taken or possessed. This Act supersedes Act 85 of 1989 because it is the later enacted of the 2 statutes.

1989 - Act 510. Amends provisions of Act 893 of 1988. Seasons for outside and inside waters are to be set by the Commission based upon technical and biological data which indicates that marketable shrimp, in sufficient quantities, are available for harvest. The Commission is required to conduct a public hearing prior to determining whether or not to open or close a regular or special season. The Commission is to give at least 3 days notice of such a hearing. At such a hearing, the Commission is to adopt written reasons for its decision which must specify the biological or technical data on which the decision is based and the market standard by which the data is evaluated. The Commission's decision is not effective prior to 72 hours after the decision is made. The closing of outside waters to shrimping is not to be construed as prohibiting or otherwise affecting trawling for finfish or underutilized species.

1989 - Act 607. Defines the inside-outside shrimp line.

1990 - Act 549. Defines the inside-outside shrimp line.

1991 - Act 259. Fishing with a butterfly net prohibited in inside waters during the closed season. No vessel shall pull more than four trawls and a test trawl in outside waters. In addition to any and all other penalties, for the second and all subsequent violation of these provisions the trawl license will be revoked and not reinstated at any time during the period for which it was issued and for one year thereafter.

1991 - Act 294. Deletes provisions requiring a wholesale dealer's agent to purchase a license and making this person responsible for any illegal transactions ensuing between the time he purchases from the shrimper and the time they

are accepted by the wholesaler for whom he is operating.

1991 - Act 931. Defines "skimmer nets" and makes them legal gear for catching shrimp. Establishes a minimum mesh size for skimmer nets of five-eights of an inch square or one and one-fourth of an inch stretched. No one on a vessel can use a double skimmer net having an individual net frame more than 16 feet measured horizontally or twelve feet measured vertically, or with a lead line measuring more than 28 feet for each net. Skimmer nets can not be tied together to exceed these specifications. Operation of a skimmer net must in no way impede or restrict normal navigation. It is illegal to use sweeper devices, leads, extensions, wings, or other attachments in conjunction with or attached to butterfly nets. Details the length of shrimp trawls that can be used in inside waters. Defines "test trawl".

1991 - Act 946. Defines the inside-outside shrimp line. Amends the white shrimp count provisions to provide that when more than 50% by weight of the saltwater shrimp taken or possessed is sea bobs or brown shrimp, then the maximum allowable amount of undersized white shrimp taken or possessed can not exceed 10% by weight of the total saltwater shrimp taken or possessed.

1992 - Act 174. Defines plumb staff beam trawls.

1992 - Act 568. Provides for the use of LORAN navigational instrument readings for determining if a person is shrimping in inside or outside waters.

1992 - Act 619. Amends the white shrimp count law.

1992 - Act 641. Defines the inside-outside shrimp line.